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Lower Bay zooplankton monitoring program : the August 1978 survey

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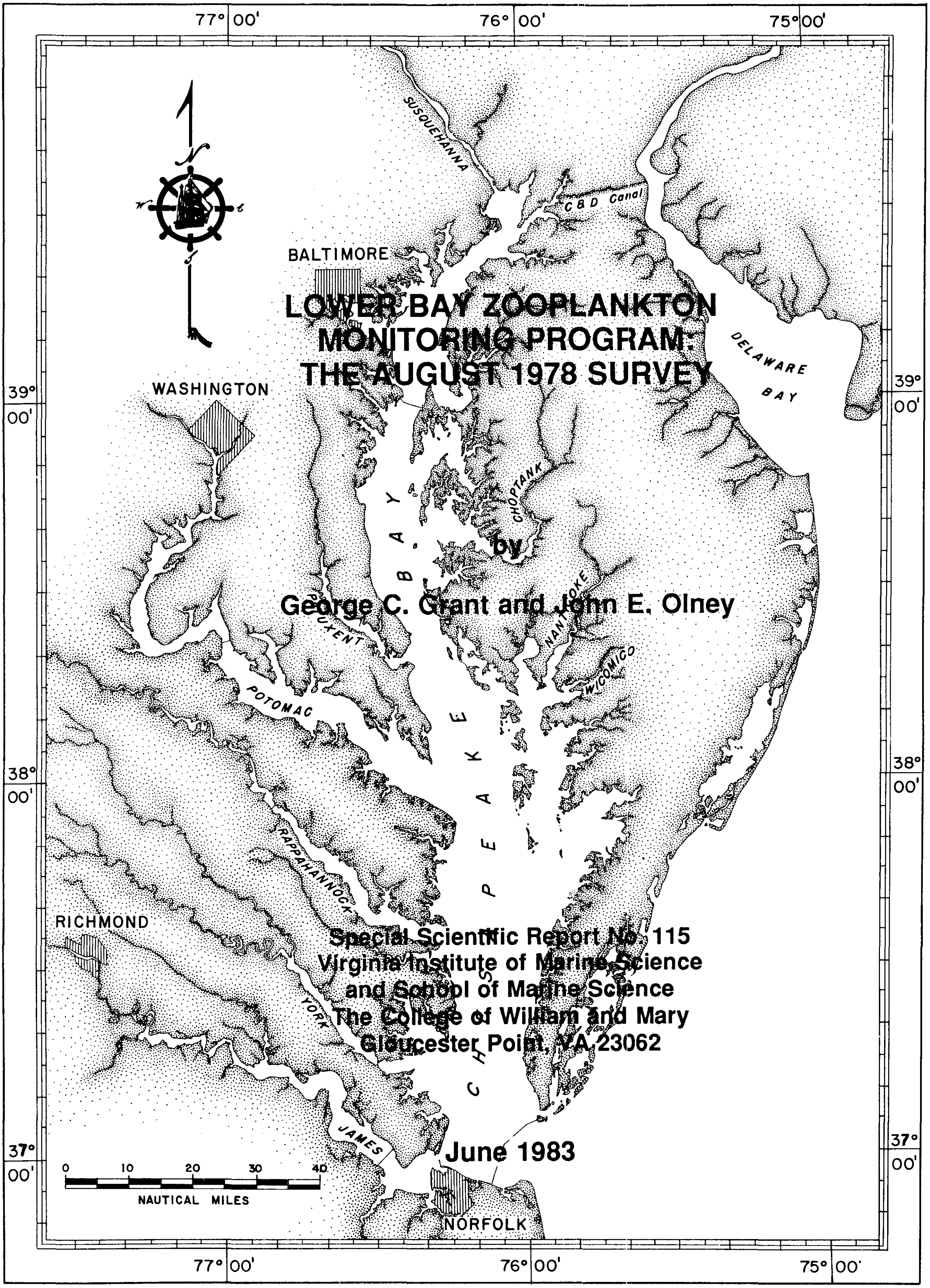

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

INTRODUCTION

Monitoring of the lower Chesapeake Bay zooplankton populations was begun in March 1978 to provide a data base needed as a prerequisite to future evaluations of faunal change. An initial report (Grant and Olney, 1979) presented the basic design and sampling techniques of the Lower Bay Zooplankton Program (LBZMP), along with results of the first winter-spring cruise.

These surveys are conducted during four months of the year, with complete taxonomic analysis in March and August and analyses limited to meroplanktonic fish eggs and larvae and decapod crustacean larvae in June and July. The present report includes results of the summer 1978 full taxonomic survey, conducted in the period 23-25 August 1978.

METHODS AND MATERIALS

Station locations for the August 1978 survey were chosen randomly as in the initial March 1978 survey, with stations evenly divided for night and daytime sampling. All sampling was conducted within a three-day period (August 23-25) from the R/V *Virginian Sea*.

At each station, an array of samplers consisting of an 18.5 cm bongo sampler (202 μm mesh nets) and a 60 cm bongo sampler with paired 202 μm and 333 μm mesh nets was obliquely towed from surface to near-bottom. Surface layer collections were obtained with a 1-meter WHOI neuston sampler (mesh size 333 μm). One of the paired 18.5 cm net collections was frozen for dry weight determinations. All other collections (four per station) were preserved in 5% buffered formalin. All nets were metered with G-O flowmeters for calculations of volume of water sampled.

Ancillary data collected at each station included (at 2-meter depth intervals): water temperature, salinity, dissolved oxygen, chlorophyll-*a*, and preserved samples for phytoplankton analyses (the latter two by the Department of Environmental Physiology). Additional observations at each station included those of meteorological conditions and tidal stage.

Laboratory Processing of Zooplankton Samples

Preserved collections were measured for displacement volume by the method of Kramer (1972), then sorted into major taxonomic categories. Larger and rarer groups were sorted from whole collections or 1/2 splits, and smaller and more abundant groups from successively smaller aliquots. Splitting was quantitative and accomplished with a VIMS Plankton Splitter (Burrell et al., 1974). Separated major taxa were then identified to species, if possible, and enumerated. Counts are reported in numbers per m^3 or 100 m^3, depending on relative abundance. Dry weights were obtained by lyophilizing frozen 18.5 cm bongo collections.

Community Analysis

Sample and species data cards, the latter for each species occurrence, were punched after completion of identifications and counts. Sample and species groups were obtained by cluster analyses (normal and inverse, respectively), using the Bray-Curtis coefficient of similarity (Bray and Curtis, 1957) and a flexible beta = -0.25 (Boesch, 1977). A nodal analysis was used to relate species clusters to sample clusters. For each collection, we have also calculated diversity (H'), evenness (J') and species richness (d).

RESULTS OF THE AUGUST 1978 CRUISE

Eighteen stations (9 each, day and night) were sampled during the period of 23 to 25 August 1978 (Fig. 1). Results are reported in three principal sections: hydrography, phytoplankton, and zooplankton, with major emphasis on the latter. Station data are listed in Table 1.

Hydrography

In our initial report in this series (Grant and Olney, 1979) percentage of river runoff in the Chesapeake Bay during the year prior to our initial survey was listed by Bay segments. A comparison with similar data for the period April-August 1978 (U.S. Geological Survey, 1978) is given below:

Bay Segments Including the Rivers	Percent of Total Mean Streamflow	
	1977	Apr-Aug 1978
Susquehanna	61.5	49.8
Upper Bay*	9.5	8.0
Potomac	14.2	19.6
York, Rappahannock and Pocomoke	5.4	8.3
James	9.4	14.3

* Including Patapsco, West, Patuxent, Chester, Choptank, Nanticoke and Wicomico rivers.

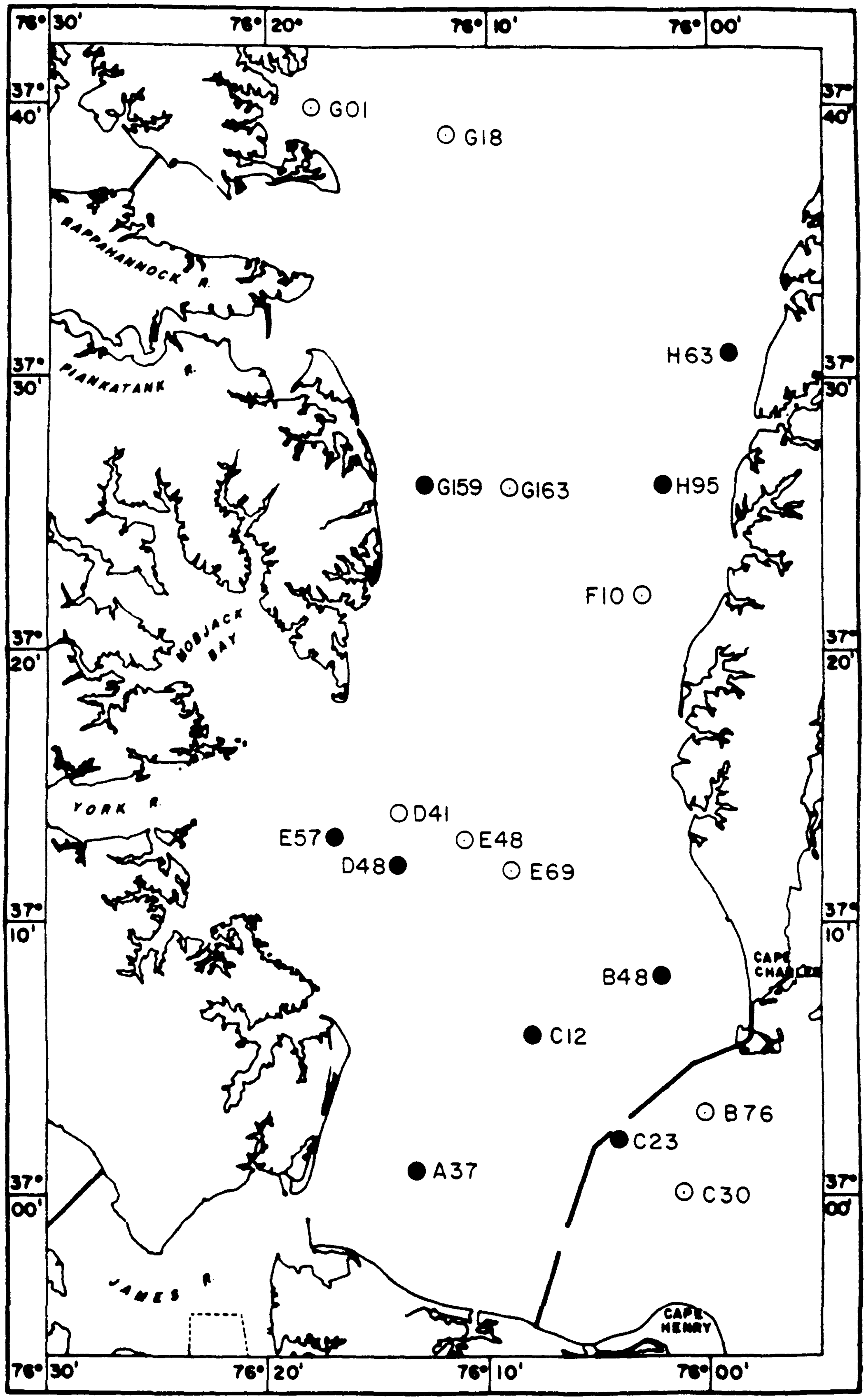

Fig. 1. Randomly selected stations sampled in lower Chesapeake Bay, 23-25 August 1978. Night and day stations indicated by filled and open circles, respectively.

Table 1. Station list and data, Lower Bay Zooplankton Monitoring Program, August 1978, R/V *Virginian Sea*.

Station	Lat. N	Long. W	Aug 1978 Date	Time (EST)	Day or Night	Station Depth (M)	Surface Temp. °C	Surface Salinity ‰
D41	37°14'	76°14'	23	1820	D	9.1	27.2	18.6
D48	37°12'	76°14'	23	1933	N	7.6	27.1	18.3
E57	37°13'	76°17'	23	2030	N	10.7	27.1	19.4
G159	37°26'	76°13'	24	0100	N	4.9	26.8	15.4
H95	37°26'	76°02'	24	0240	N	12.2	26.2	17.8
H63	37,31'	75°59'	24	0330	N	7.6	25.5	21.3
G01	37°40'	76°18'	24	0730	D	6.7	27.0	14.4
G18	37°39'	76°12'	24	0845	D	11.3	27.0	15.5
G163	37°26'	76°09'	24	1100	D	11.0	27.4	14.9
F10	37°22'	76°03'	24	1340	D	12.5	27.9	16.7
E48	37°13'	76°11'	24	1640	D	10.1	27.8	18.7
E69	37°12'	76°09'	24	1740	D	10.1	27.6	18.2
A37	37°01'	76°13'	24	2155	N	6.1	26.3	20.9
C12	37°06'	76°08'	25	0000	N	13.1	26.6	18.5
B48	37°08'	76°02'	25	0130	N	6.7	26.0	21.0
C23	37°02'	76°04'	25	0335	N	15.2	25.4	21.8
B76	37°03'	76°00'	25	0530	D	6.4	25.5	23.1
C30	37°00'	76°01'	25	0720	D	13.7	25.5	22.0

Streamflow was above average in April, May, July and August, exceptionally so in May 1978. Relative contribution by lower Bay tributaries was higher than in 1977. The increased contributions by lower Bay rivers was reflected in climatological data from the "Tidewater region" of Virginia (Environmental Data Service, 1978) with above average precipitation in April, May and June (+ 2.48" in May), below average in July (-0.78"). Air temperatures in the region were below average in April-July, and above average in August.

Salinity of lower Bay waters in August 1978 was mostly in the polyhaline (> 18 $^{o}/oo$) range. Mesohaline salinities were limited to the surface at station F10, the upper 2 meters at H95, the upper 4 meters at G163, and all sampled depths at G01, G18 and G159 (Table 2). Salinity higher than 30 $^{o}/oo$ was limited to station C30 in the Bay mouth, at 10-16 meters depth. Temperature of entering coastal waters was 24-25°C near the bottom at the Bay mouth; surface temperatures at higher estuarine stations exceeded 27°C. Temperatures and salinity at the surface are shown in Figs. 2A and B.

Mean surface temperature and salinity for the study area in August were 26.66°C and 18.69 $^{o}/oo$; for all depths sampled the respective means were 26.10°C and 21.88 $^{o}/oo$ (N=103). Water temperature was considerably warmer (+ 1 to 2°C) than in August of 1971 and 1972 (Jacobs, 1978); salinity was closely similar to observations in August 1971, and higher than those of August 1972 when flooding from Tropical Storm Agnes was still freshening the lower Bay (Grant et al., 1977). Temperature-salinity relationships at August 1978 stations are shown in Figure 3.

Table 2. Temperature (°C), salinity (°/oo) and dissolved oxygen (mg/l), lower Chesapeake Bay, August 23-25, 1978.

Station	Measurement	Surface	2	4	6	8	10	12	14	16
		Depth (meters)								
A37	t	26.3	26.3	26.4	26.3					
	sal.	20.86	20.94	21.22	28.50					
	DO_2	6.6	6.5	6.4	6.3					
B48	t	26.0	26.1	26.1	26.1					
	sal.	20.97	20.79	20.79	20.78					
	DO_2	7.4	7.0	--	7.4					
B76	t	25.5	25.6	25.5	25.3	25.3	25.3	25.4		
	sal.	23.10	23.00	24.20	27.29	28.91	28.94	29.00		
	DO_2	7.1	6.8	6.8	6.6	6.7	6.8	7.1		
C12	t	26.6	26.6	26.6	25.1	24.9	24.6	24.2	24.2	
	sal.	18.49	18.44	18.51	24.98	26.79	28.33	29.46	29.49	
	Do_2	8.1	7.5	7.6	6.5	6.5	5.7	5.8	5.4	
C23	t	25.4	25.6	25.6	25.5	25.4	25.3	25.1	24.8	
	sal.	21.75	21.79	22.08	24.72	26.03	27.34	27.01	29.00	
	DO_2	7.4	--	6.8	6.9	6.5	6.7	6.6	6.2	
C30	t	25.5	25.5	25.7	25.3	25.2	24.8	24.5	24.5	24.3
	sal.	22.05	21.84	23.48	25.68	29.38	30.30	30.88	31.07	31.15
	DO_2	7.1	6.8	6.5	7.3	6.9	6.9	8.0	6.5	5.9
D41	t	27.2	27.2	27.0	26.6	26.7				
	sal.	18.58	17.94	18.18	19.12	19.60				
	DO_2	8.1	8.2	7.9	6.3	3.9				
D48	t	27.1	27.3	26.5	26.5					
	sal.	18.31	18.28	19.85	19.90					
	DO_2	8.0	8.3	5.6	5.6					
E48	t	27.8	27.6	27.3	26.3	24.8	24.2			
	sal.	18.67	18.50	18.50	21.84	27.72	27.88			
	DO_2	8.0	8.0	7.7	--	5.1	4.9			

Table 2. (continued)

Station	Measurement	Surface	Depth (meters) 2	4	6	8	10	12	14	16
E57	t	27.1	27.3	27.3	27.4					
	sal.	19.43	19.41	19.49	23.76					
	DO_2	7.5	7.1	7.2	7.6					
E69	t	27.6	27.6	27.4	25.2	24.6	24.4			
	sal.	18.22	18.05	18.05	25.43	28.19	28.31			
	DO_2	8.0	8.1	8.1	6.9	5.9	5.6			
F10	t	27.9	26.8	26.7	26.0	25.7	25.3	25.3		
	sal.	16.72	18.58	18.15	24.74	25.45	27.19	27.02		
	DO_2	7.8	8.0	7.1	6.5	5.2	5.2	5.1		
G01	t	27.0	27.2	27.3	27.2					
	sal.	14.41	14.25	14.26	14.69					
	DO_2	6.0	6.5	5.9	4.7					
G18	t	27.0	27.0	27.1	27.1	27.0	26.9			
	sal.	15.49	15.46	15.51	15.50	15.67	16.78			
	DO_2	7.2	7.0	7.1	7.1	6.9	6.6			
G159	t	26.8	26.8	26.9	26.8					
	sal.	15.45	15.37	15.40	17.86					
	DO_2	6.2	6.1	4.3	6.2					
G163	t	27.4	27.4	26.9	26.8	25.9	25.7			
	sal.	14.88	14.85	17.43	19.61	22.69	25.09			
	DO_2	7.2	7.4	5.8	5.3	3.3	3.2			
H63	t	25.5	25.6	25.7	25.6					
	sal.	21.29	21.13	21.11	21.13					
	DO_2	--	6.5	6.6	6.7					
H95	t	26.2	26.3	25.4	25.5	25.4	25.4	25.4		
	sal.	17.79	17.80	23.76	24.73	24.97	25.11	25.33		
	DO_2	7.1	6.8	4.9	4.8	4.8	4.7	4.8		

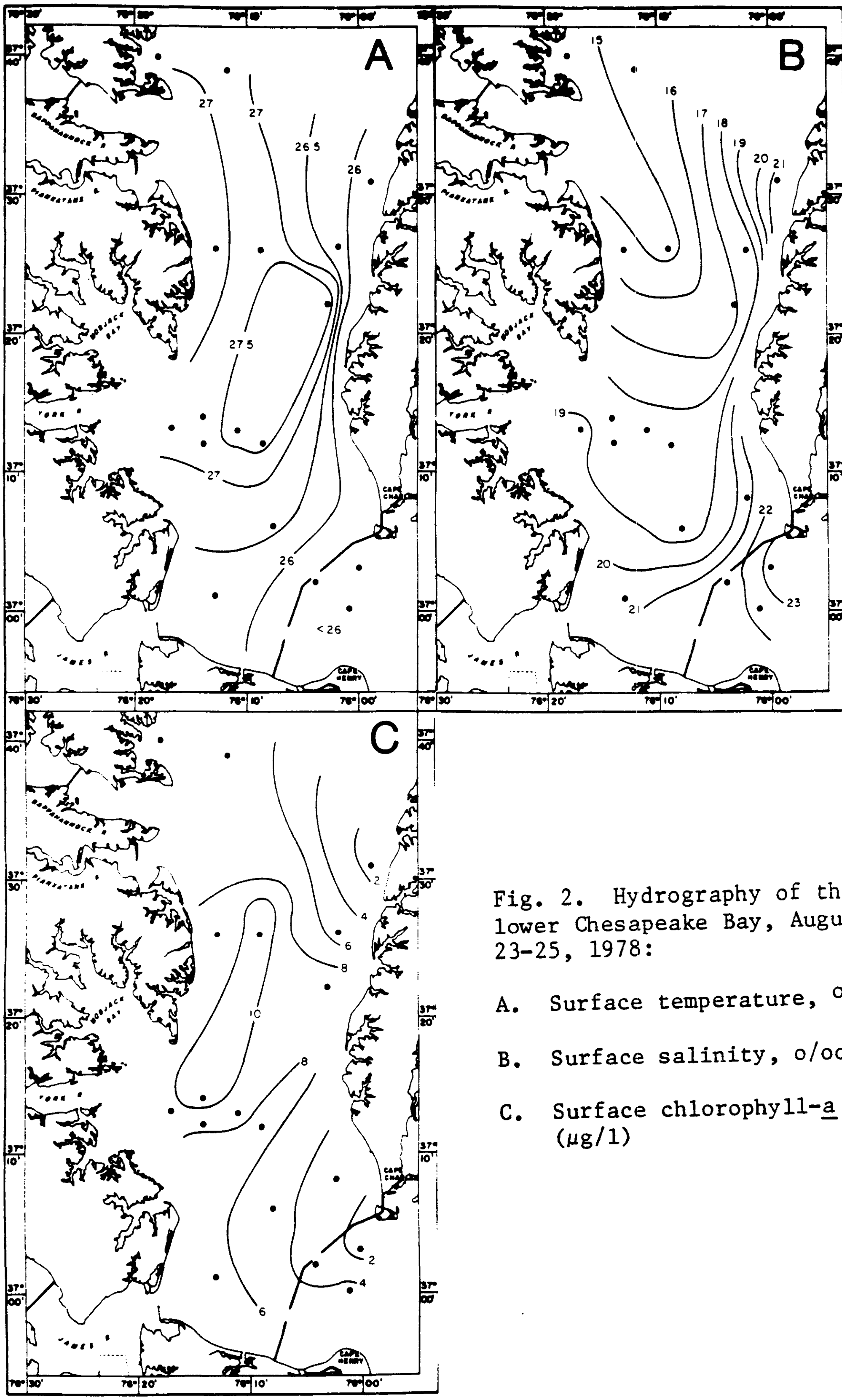

Fig. 2. Hydrography of the lower Chesapeake Bay, August 23-25, 1978:

A. Surface temperature, ^{o}C;

B. Surface salinity, o/oo;

C. Surface chlorophyll-a ($\mu g/l$)

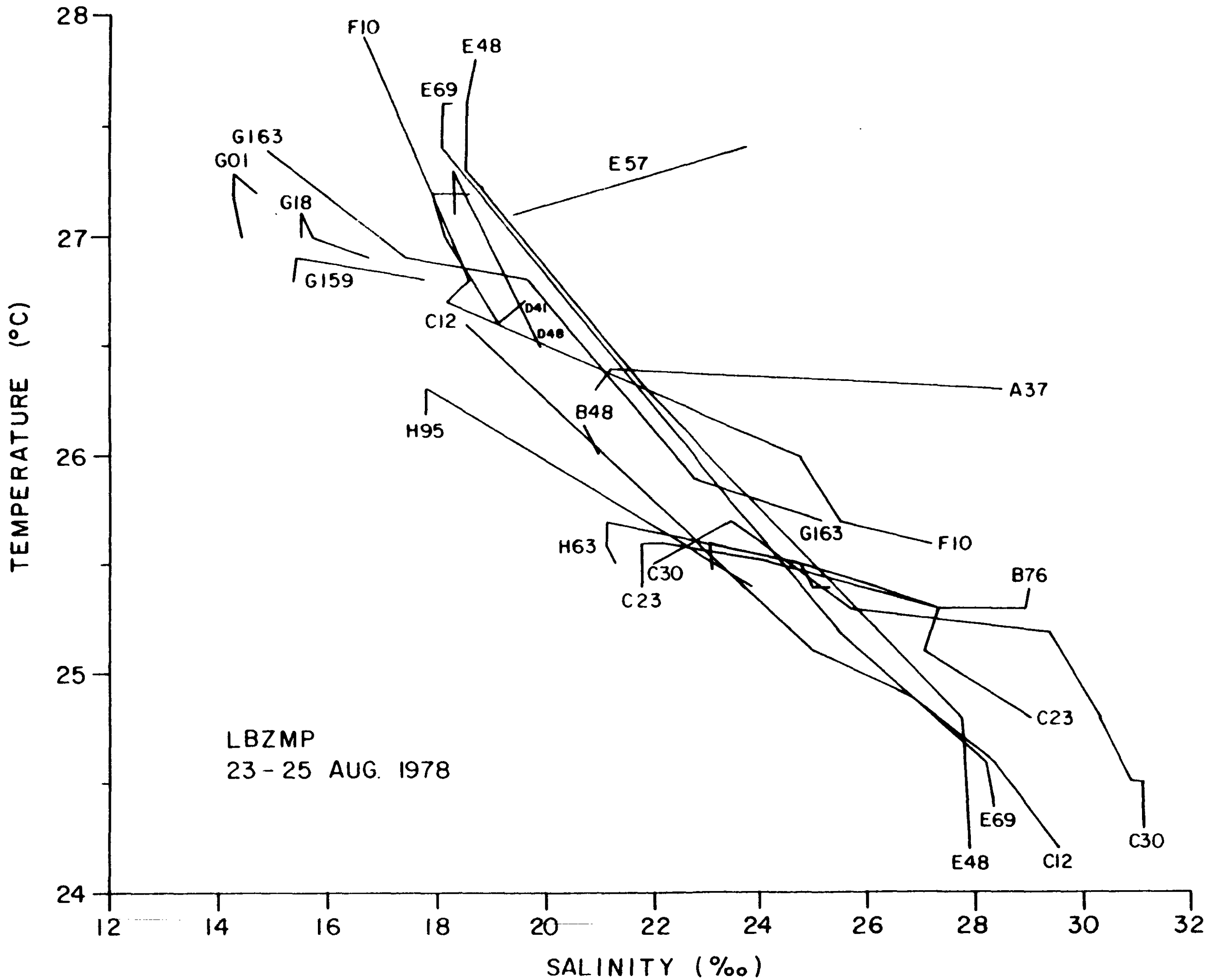

Fig. 3. Temperature-salinity relationship through the water column at each of the 18 sampled stations.

There was no evidence of severe oxygen depletion during this survey. The lowest oxygen content measured was 3.2 mg/l at the bottom at station G163. Most measurements were above 6 mg/l (see Table 2).

Phytoplankton

Observations on phytoplankton by the Department of Environmental Physiology in the lower Chesapeake Bay in August 1978 included measurements of chlorophyll-*a* at the surface and at several subsurface depths. Since the latter data are being accumulated for a separate report, only the surface chlorophyll-*a* observations are reported here (Fig. 2C). Surface chlorophyll ranged from 1.45 to 11.16 μg/l, with highest measurements occurring in the middle and western portion of the sampling area. The range of observed surface chlorophyll-*a* measurements was similar to that of March 1978 (Grant and Olney, 1979).

Zooplankton

Biomass

The displacement volumes in ml/m^3 for zooplankton collections obtained with the four net types are listed in Table 3. Among the scattered observations on dry weight, highest biomass (> 1,000 mg/m^3) estimates were twice those measured in March 1978. There was no apparent areal pattern in dry weight measurements, or correlation with measurements of displacement volume.

Table 3. Displacement volume (ml/m^3) of surface and subsurface collections, August 1978. Dry weight (mg/m^3) measurements from 18.5 cm bongo nets given in parentheses.

Station	N333	60B333	60B202	18.5B202
A37	*	1.74	3.09	8.36 (1,184)
B48	1.32	0.88	2.26	4.31 (85)
B76	0.57	1.14	2.80	6.90
C12	0.77	1.29	2.42	4.26 (211)
C23	1.92	2.04	2.14	* (361)
C30	1.75	1.40	1.37	*
D41	*	*	2.25	4.24 (121)
D48	2.47	1.17	1.16	2.02 (53)
E48	0.81	0.94	2.20	4.18
E57	0.62[1/]	7.46	*	10.43
E69	0.32	0.81	3.09	7.64
F10	0.50	*	0.30	2.37 (223)
G01	0.30	0.63	0.71	6.22
G18	0.27	1.02	1.63	10.23 (621)
G159	16.88	no sample	2.37	7.17 (1,281)
G163	1.32	1.31	1.23	0.92 (98)
H63	*	2.29	1.67	4.46 (364)
H95	1.73	1.25	1.23	1.29

* no measurement

1/ not including 14 qts atherinids

Generally higher estimates of biomass (displacement volume) from the 18.5 m bongo samplers (Table 3) are only partially explained by the 202 μm mesh size of nets. Mesh size differences in collections are best examined by comparison of estimates from paired 333 μm and 202 μm 60 cm bongo nets. The ratio of biomass estimates from 60 cm collections, 202 μm: 333 μm nets, varied from 0.73 to 3.81 with 9 of 13 available comparisons having a ratio greater than 1.0. Only one of 12 similar comparisons of 18.5 cm 202 μm mesh with 60 cm 333 μm mesh collections showed a ratio less than 1.0, with some estimates 10 times those of the coarser net.

Biomass in neuston collections is heavily influenced by time of day, with daytime collections typically light and night collections reflecting the rise into the surface layer of several forms of zooplankton (cf. Table 1). The range of biomass estimates was accordingly very wide, 0.03-16.9 ml/m^3, excluding 14 quarts of atherinids from one night sample.

Distribution and Abundance of Zooplankton

In contrast to March 1978 collections where some 90 species of zooplankton were identified, August 1978 collections included over 175 taxa (Table 4). Particularly speciose major taxa included the polychaetes, molluscs, copepods, amphipods, decapod larvae and fish larvae. Many of these taxa occurred at every sampled station: larvae of Spionidae (Polychaeta); unidentified gastropods; the copepods *Acartia tonsa*, *Labidocera aestiva* and *Pseudodiaptomus coronatus*; unidentified barnacle larvae; *Neomysis americana* (Mysidacea); several

Table 4. Checklist of species and occurrence of zooplankton in the lower Chesapeake Bay, August 23-25, 1978.

	Station																	
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95
COELENTERATA																		
Unid. hydromedusae		X							X									
Bougainvillea sp.					X													
Cunina octonaria					X													
Dipurena strangulata	X																	
Liriope tetraphylla					X													
Nemopsis bachei	X		X					X						X	X	X	X	X
Obelia sp.	X				X													
Muggiaea kochei			X	X	X	X			X									X
Aurelia aurita	X							X		X								
Chrysaoura quinquecirrha	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
TURBELLARIA																		
Unid. flatworms										X								X
ANNELIDA																		
Unid. polychaetes	X	X		X						X								X
Glycera sp.		X								X								
Gyptis vittata					X													
Harmothoe sp.	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Hesionidae			X		X										X			
Nereis succinea		X		X	X				X	X	X				X	X	X	
Paraprionospio pinnata				X									X				X	
Phyllodocidae					X	X												
Polydora sp.	X				X	X		X	X	X					X	X	X	X
Polynoidae		X			X				X									
Pseudeurythoe ambigua				X													X	X
Spionidae larvae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Syllidae				X	X			X										
Terebellidae	X			X	X		X	X	X	X		X		X	X	X	X	X
Tomopteris helgolandica						X												

Table 4. (continued)

	Station																	
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95
MOLLUSCA																		
Unid. bivalve			X											X				
Unid. gastropod	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Alvania sp.												X	X					
Caecum pulchellum			X															
Cerithiidae					X													
Cerithiopsis sp.		X	X															
Crassostrea virginica	X				X					X	X					X		
Crepidula sp.			X	X	X	X			X		X					X		X
Donax variabilis							X											
Epitonium sp.	X	X		X	X		X	X	X	X	X			X	X	X		X
Littorina irrorata	X	X	X		X		X	X		X		X			X		X	X
Loliginidae						X						X						
Loligo pealeii					X													
Lolliguncula brevis					X						X	X						
Lyonsia hyalina										X								
Mulinia lateralis	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Nassarius obsoletus	X		X		X		X							X				X
Nassarius vibex	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X
Naticidae		X	X	X	X	X			X									X
Pholadidae				X							X	X						
Tellina agilis		X		X	X					X								X
MEROSTOMATA																		
Limulus polyphemus				X											X		X	
CRUSTACEA																		
Cladocera																		
Evadne tergestina		X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Penilia avirostris	X	X	X	X	X	X	X	X	X		X	X				X		X
Ostracoda																		
Unid. ostracods									X									X

Table 4. (continued)

	Station																	
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F1-	G01	G18	G159	G163	H63	H95
CRUSTACEA (continued)																		
Copepoda																		
Unid. calanoids									X									
Acartia tonsa	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Centropages hamatus						X			X									
Centropages typicus			X	X	X	X												
Centropages velificatus		X	X		X	X												
Eucalanus crassus			X		X	X												
Eucalanus pileatus					X	X			X									
Labidocera aestiva	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Paracalanus indicus						X												
Paracalanus quasimodo			X	X	X	X												
Parvocalanus crassirostris	X	X	X	X	X		X		X		X	X				X		X
Pseudodiaptomus coronatus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Temora turbinata			X			X	X				X			X		X		
Euterpina acutifrons																X		
Unid. cyclopoid				X														
Corycaeus speciosus			X		X		X				X							
Oithona spp.	X		X						X				X					
Oncaea mediterranea												X						
Argulus alosae							X			X				X	X		X	
Caligus chelifer						X												
Cirripedia																		
Unid. barnacle larvae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Stomatopoda																		
Squilla empusa larvae	X	X	X		X	X	X				X	X					X	
Mysidacea																		
Metamysidopsis mexicana	X	X	X	X	X	X	X	X			X	X	X	X			X	X
Mysidopsis bigelowi	X	X	X	X	X	X		X	X	X					X	X	X	
Neomysis americana	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cumacea																		
Cyclaspis sp.		X																
Leucon americanus										X					X			X
Mancocuma sp.		X	X		X													
Oxyurostylis smithi	X	X		X	X			X		X		X						X

Table 4. (continued)

	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95
	Station																	
CRUSTACEA (continued)																		
Isopoda																		
Unid. isopod		X									X					X		X
Aegathoa medialis	X					X		X		X		X					X	
Aegathoa oculata	X	X		X	X	X	X	X		X		X	X		X	X	X	X
Edotea triloba	X	X			X					X					X			X
Idotea baltica	X																X	
Lironeca ovalis	X							X		X					X		X	
Sphaeroma quadridentatum													X		X	X		
Amphipoda																		
Unid. gammarid							X						X				X	X
Ampelisca abdita				X													X	X
Ampelisca agassizi				X						X							X	
Ampelisca vadorum		X		X				X		X								X
Ampelisca verrilli										X								
Unid. ampeliscid			X															
Ampithoe sp.										X								X
Ampithoe longimana		X	X	X		X	X	X	X	X								X
Ampithoe valida	X																X	
Atylus minikoi			X															
Batea catharinensis			X	X		X											X	
Corophium sp.			X															
Corophium lacustre			X	X	X	X		X			X			X		X	X	X
Cymadusa compta													X					
Elasmopus levis								X										
Gammarus mucronatus	X	X	X	X			X	X	X	X			X	X	X		X	X
Idunella sp.	X				X					X								
Jassa falcata						X												
Lestrigonus bengalensis		X	X	X	X	X			X		X							
Melita sp.				X					X	X			X		X		X	X
Melita nitida	X														X			
Microprotopus raneyi		X	X	X	X	X												X
Paracaprella tenuis										X								
Parapleustes aestuarius					X					X								X
Phoxocephalus spinosus					X					X								X
Synchelidium americanum		X																

Table 4. (continued)

	Station																	
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95
CRUSTACEA (continued)																		
Decapoda																		
Unid. brachyuran larvae	X	X	X	X	X	X			X	X		X					X	
Unid. pinnotherid		X	X		X	X		X	X	X	X	X	X		X		X	X
Unid. thalassinid				X														
Unid. xanthid	X		X			X	X	X		X	X	X	X		X	X		X
Unid. caridean					X													
Alpheus ("heterochaelis")												X			X			
Alpheus normanni		X	X	X	X	X		X	X		X	X				X		X
Callianassa sp.										X							X	
Callianassa atlantica		X		X	X	X	X	X									X	
Callianassa biformis	X	X	X	X	X	X	X	X		X	X	X	X				X	
Callinectes sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Callinectes sapidus																	X	
Crangon septemspinosa		X	X	X	X	X				X		X			X		X	
Emerita talpoida												X	X			X	X	X
Euceramus praelongus	X		X	X	X	X		X	X		X			X		X		
Eurypanopeus depressus															X	X		
Hexapanopeus angustifrons	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Libinia sp.	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X
Libinia dubia	X	X	X				X	X									X	
Libinia emarginata					X					X						X		
Lucifer faxoni	X	X	X	X	X	X		X			X	X		X	X		X	X
Lysmata wurdmanni												X						
Naushonia crangonoides			X		X							X				X		
Neopanope sayi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ogyrides limicola	X				X	X	X	X		X		X		X	X	X	X	X
Ovalipes sp.	X	X		X	X	X												
Ovalipes ocellatus		X	X		X	X			X		X	X						
Ovalipes stephensoni						X												
Pagurus sp.					X										X			
Pagurus longicarpus	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X
Palaemonetes sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Panopeus herbstii	X	X	X	X	X	X	X		X	X		X	X	X		X	X	X

Table 4. (continued)

	Station																	
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95
CRUSTACEA (continued)																		
Decapoda (continued)																		
Pinnixa chaetopterana	X		X	X	X	X	X	X	X	X	X	X		X		X	X	X
Pinnixa cylindrica					X													
Pinnixa sayana	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pinnotheres maculatus	X	X	X				X	X	X	X	X	X	X	X	X	X	X	
Pinnotheres ostreum	X	X	X	X	X		X	X		X	X	X	X		X	X	X	
Portunus sp.			X															
Sesarma cinereum												X						
Uca sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Upogebia affinis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PHORONIDA																		
Unid. phoronid larvae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHAETOGNATHA																		
Sagitta enflata				X							X	X						
Sagitta hispida	X	X	X	X				X		X				X	X		X	
Sagitta tenuis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TUNICATA																		
Dolioletta gegenbauri									X									
Oikopleura sp.			X	X	X				X									
PISCES																		
Unid. fish larvae					X				X									
Anchoa sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Anchoa hepsetus						X												
Anchoa mitchilli	X	X		X	X			X		X				X	X	X	X	X
Astroscopus guttatus										X						X		
Atherinidae	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X
Centropristis striata		X			X	X								X				

Table 4. (continued)

	Station																		
	A37	B48	B76	C12	C23	C30	D41	D48	E48	E57	E69	F10	G01	G18	G159	G163	H63	H95	
PISCES (continued)																			
Chasmodes bosquianus														X					
Cynoscion nebulosus					X														
Cynoscion regalis	X	X		X	X	X			X		X	X			X		X	X	
Etropus microstomus			X		X	X													
Gobiesox strumosus	X	X												X		X	X		
Gobiosoma sp.	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
Gobiosoma bosci										X									
Gobiosoma ginsburgi	X	X		X			X	X	X	X						X	X	X	
Hemiramphus brasiliensis		X																	
Hypsoblennius hentzi	X		X	X	X	X	X	X	X	X	X				X	X	X	X	X
Membras martinica	X	X						X		X					X	X	X	X	X
Menticirrhus sp.	X		X	X	X														
Menticirrhus americanus				X											X				
Microgobius thalassinus	X														X				
Unid. ophidiid			X	X															
Peprilus paru				X						X						X			
Peprilus triacanthus		X	X		X	X					X	X		X				X	
Unid. pleuronectiform					X														
Prionotus sp.		X	X	X	X	X													
Prionotus carolinus																X			
Rissola marginata			X		X	X													
Symphurus plagiusa		X	X		X	X													
Syngnathus fuscus		X		X	X	X		X			X			X	X	X	X	X	
Trinectes maculatus																			
Fish Eggs	X			X			X	X	X		X	X	X		X	X	X		
Unid. eggs	X																		
Anchoa mitchilli	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Sciaenidae	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	
Symphurus plagiusa			X		X	X			X		X								
Trinectes maculatus		X	X		X	X	X	X	X	X	X		X			X	X		

decapod crustacean larvae, including Callinectes sp., Hexapanopeus angustifrons, Neopanope sayi, Palaemonetes sp., Pinnixa sayana, Uca sp. and Upogebia affinis; unidentified phoronid larvae (Phoronida); Sagitta tenuis (Chaetognatha); and the eggs, larvae and adults of Anchoa mitchilli (bay anchovy). Several other taxa were missing from collections at only one or two of the 18 stations, notably Chrysaoura quinquecirrha (the stinging nettle), the scale-worm Harmothoe sp., molluscs Nassarius vibex and Mulinia lateralis decapod larvae of Libinia sp. and Panopeus herbstii, and the larvae of fishes in Atherinidae, Sciaenidae and Gobiosoma sp.

The distribution and abundance of individual taxa will be briefly discussed below under major taxonomic categories.

Coelenterata. Among the larger and more conspicuous jellyfishes, the cold-water northern Cyanea capillata characteristic of March plankton in Chesapeake Bay (Grant and Olney, 1979) had been replaced by Aurelia aurita (moon jelly) and Chrysaoura quinquecirrha (the troublesome stinging nettle). Though never very dense in these open-Bay August collections (Table 5), with a maximum observed density of 13/100 m^3, Chrysaoura was found at all but one of the 18 stations. Aurelia was less frequent and abundant.

The most abundant smaller coelenterates in summer collections included the siphonophore Muggiaea kochei (max. density of $58/m^3$ at the Bay mouth) and the estuarine hydromedusa Nemopsis bachei. Ctenophores were absent from the collections.

Table 5. Density estimates (numbers per m^3) for coelenterates in lower Chesapeake Bay, August 1978.

Taxa	Mean Density (No/m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/m^3	Station and net
Unidentified hydromedusae	*	*	0	0	<0.01	--
Dipurena strangulata	0	0	*	0	<0.01	--
Bougainvillea sp.	0	0	*	0	<0.01	--
Nemopsis bachei	*	*	**	0.16	1.74	G159 18.5B202
Obelia sp.	0	0	*	0	0.07	C23 60B202
Liriope tetraphylla	0	0	*	0	0.34	C23 60B202
Cunina octonaria	0	0	*	0	0.10	C23 60B202
Muggiaea kochei	**	1.18	0.48	**	58.39	C23 60B333
Chrysaoura quinquecirrha	*	**	**	0	0.13	E69 60B202
Aurelia aurita	*	*	*	0	0.06	A37 60B333

* less than $0.01/m^3$

** less than $0.1/m^3$

Turbellaria. Unidentified flatworms were taken in only two collections, both with 18.5 cm 202 μm mesh bongo nets, at statons E57 and H95.

Annelida. The most abundant and widely distributed polychaete in August collections was the larva of Spionidae. Highest densities (Fig. 4A) were limited to the Bay mouth and off the mouth of the James River. Spionid larvae were also abundant and common in March 1978 collections (Grant and Olney, 1979). These small larvae were more efficiently captured in 202 μm mesh nets, with a maximum recorded density of $36/m^3$ observed at staton A37 (Table 6). Small-mesh nets were also better estimators for other abundant polychaetes, including terebellids, polynoids, and *Polydora* spp.

Although *Nereis succinea* was taken in all net types, the majority of captures occurred in neuston nets and at night. The maximum recorded abundance, however, was only $13/100\ m^3$.

Several of the polychaetes taken in August were also observed in March 1978 plankton collections: *Glycera* sp., *Harmothoe* sp., *Paraprionospio pinnata*, *Polydora* spp., spionid larvae and *Tomopteris helgolandica*. No leeches were found in summer collections.

Mollusca. Molluscan taxa in the expanded summer 1978 list (Table 7) include only three repeats of those found in March collections: *Littorina irrorata*, *Mulinia lateralis* and *Tellina agilis*, reflecting the meroplanktonic increase of these forms in warm water. *M. lateralis* (Fig. 4B) and unidentified gastropods (Fig. 4C) were the

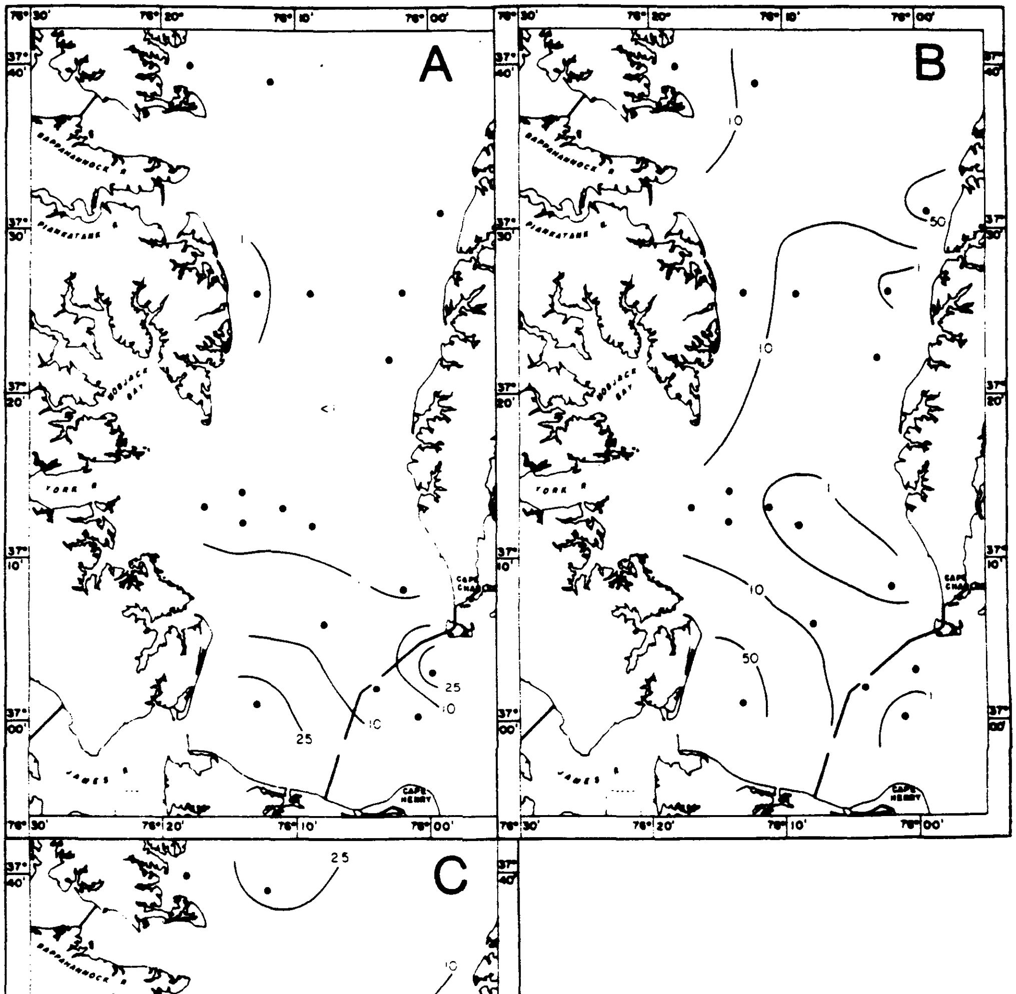

Fig. 4. Distribution and abundance (number per m^3) in 60 cm bongo subsurface collections:

A. Spionid larvae (202 μm mesh);

B. <u>Mulinia lateralis</u> (202 μm mesh);

C. Unid. gastropods (333 μm mesh).

Table 6. Density estimates (numbers per m^3) for annelids in lower Chesapeake Bay plankton, August 1978.

Taxa	Mean Density (No/m^3) N333	60B333	60B202	18.5B202	Maximum Density No/m^3	Station and net
Unidentified polychaetese	*	*	*	0	0.07	B48 60B333
Glycera sp.	0	*	*	0	0.02	E57 60B202
Gyptis vittata	0	*	0	0	0.11	C23 60B333
Harmothoe sp.	*	**	0.10	0.19	0.77	A37 60B202
Obelia sp.	0	0	*	0	0.07	C23 60B202
Hessionidae	0	0	**	0	0.57	B76 60B202
Nereis succinea	*	*	*	*	0.13	C23 N333
Paraprionospio pinnata	*	*	0	0	0.07	B48 60B333
Phyllodocidae	0	0	**	**	0.27	C30 60B202
Polydora spp.	0	*	0.14	0.29	4.91	A37 18.5B202
Polynoidae	*	0	*	0.41	8.15	B48 18.5B202
Pseudeurythoe ambigua	0	*	*	*	0.14	H63 18.5B202
Spionidae (see Fig. 4A)	**	**	3.60	2.81	36.02	A37 60B202
Syllidae	*	0	*	0	<0.01	--
Terebellidae	**	**	0.71	0.44	11.50	A37 60B202
Tomopteris helgolandica	0	*	0	0	0.01	C30 60B333

* less than $0.01/m^3$

** less than $0.1/m^3$

Table 7. Density estimates (numbers per m^3) of molluscs in lower Chesapeake Bay plankton, August 1978.

Taxa	Mean Density (No/m^3) N333	60B333	60B202	18.5B202	Maximum Density No/m^3	Station and net
Unidentified bivalves	0	*	**	0	0.01	G18 18.5B202
Unidentified gastropods (see Fig. 4C)	1.04	6.82	9.22	16.49	77.84	G18 18.5B202
<u>Alvania</u> sp.	*	0	0	0	0.05	F10 N333
<u>Caecum</u> <u>pulchellum</u>	*	0	0	0	0.07	B76 N333
Cerithiidae	0	0	*	0	0.03	C23 60B202
<u>Cerithiopsis</u> sp.	*	*	0	0	0.06	B48 60B333
<u>Crassostrea</u> <u>virginica</u>	*	0	*	0.65	9.20	G163 18.5B202
<u>Crepidula</u> sp.	0	**	0.15	0.53	7.36	G163 18.5B202
<u>Donax</u> <u>variabilis</u>	0	0	*	0	0.01	D41 60B202
<u>Epitonium</u> sp.	**	**	**	0.22	1.84	G163 18.5B202
<u>Littorina</u> <u>irrorata</u>	*	**	**	**	0.77	H63 60B202
Loliginidae	0	*	*	0	0.01	C30 60B333
<u>Loligopealeii</u>	0	0	*	0	0.03	C23 60B202
<u>Lolliguncula</u> <u>brevis</u>	0	*	*	0	0.04	C23 60B333
<u>Lyonsia</u> <u>hyalina</u>	0	0	*	0	0.14	E57 60B202
<u>Mulinia</u> <u>lateralis</u> (see Fig. 4B)	1.27	1.13	12.86	18.69	106.05	G18 18.5B202
<u>Nassarius</u> <u>obsoletus</u>	*	0	*	*	0.18	A37 18.5B202
<u>Nassarius</u> <u>vibex</u>	0.40	0.48	0.75	1.92	7.14	C23 18.5B202
Naticidae	**	**	**	**	0.56	C23 60B333
Pholadidae	*	*	0.01	0	0.17	F10 60B202
<u>Tellina</u> <u>agilis</u>	0	*	*	**	0.65	H95 18.5B202

* less than $0.01/m^3$

** less than $0.1/m^3$

most abundant molluscs, the former found in greatest density in shallow stations, the latter in deceasing abundance from uppermost sampled Bay stations to the Bay mouth. Maximum densities were $106/m^3$ and $78/m^3$, respectively. With the exception of the squids found near the Bay mouth, the coastal molluscs prevalent in March 1978 collections were generally absent in August.

Merostomata. Larvae of the horseshoe crab, *Limulus polyphemus* were taken at three stations, C12, G159 and H63, predominantly at the surface at night. Maximum observed density ($0.43/m^3$) occurred in a neuston collection at station H63; overall density in neuston collections was only $0.03/m^3$.

Cladocera. Two species of cladocerans were found at most of the sampled stations. *Evadne tergestina* (Fig. 5A) and *Penilia avirostris* (Fig. 5B) were both most abundant in the eastern half of the Bay and near the Bay mouth, apparently favoring higher salinities. Distribution of the two species was very similar, with abundances less than $1/m^3$ occurring at northern- and western-most stations.

Ostracoda. Unidentified ostracods occurred at only two locations, with only single specimens found in each of the net types. This order of Crustacea, primarily benthic in the estuarine environment, occurs only incidentally in plankton collections.

Copepoda. This group contains the most abundant species found in summer Chesapeake Bay zooplankton collections. *Acartia tonsa*, the most abundant copepod, was found in densities less than $1,000/m^3$ only

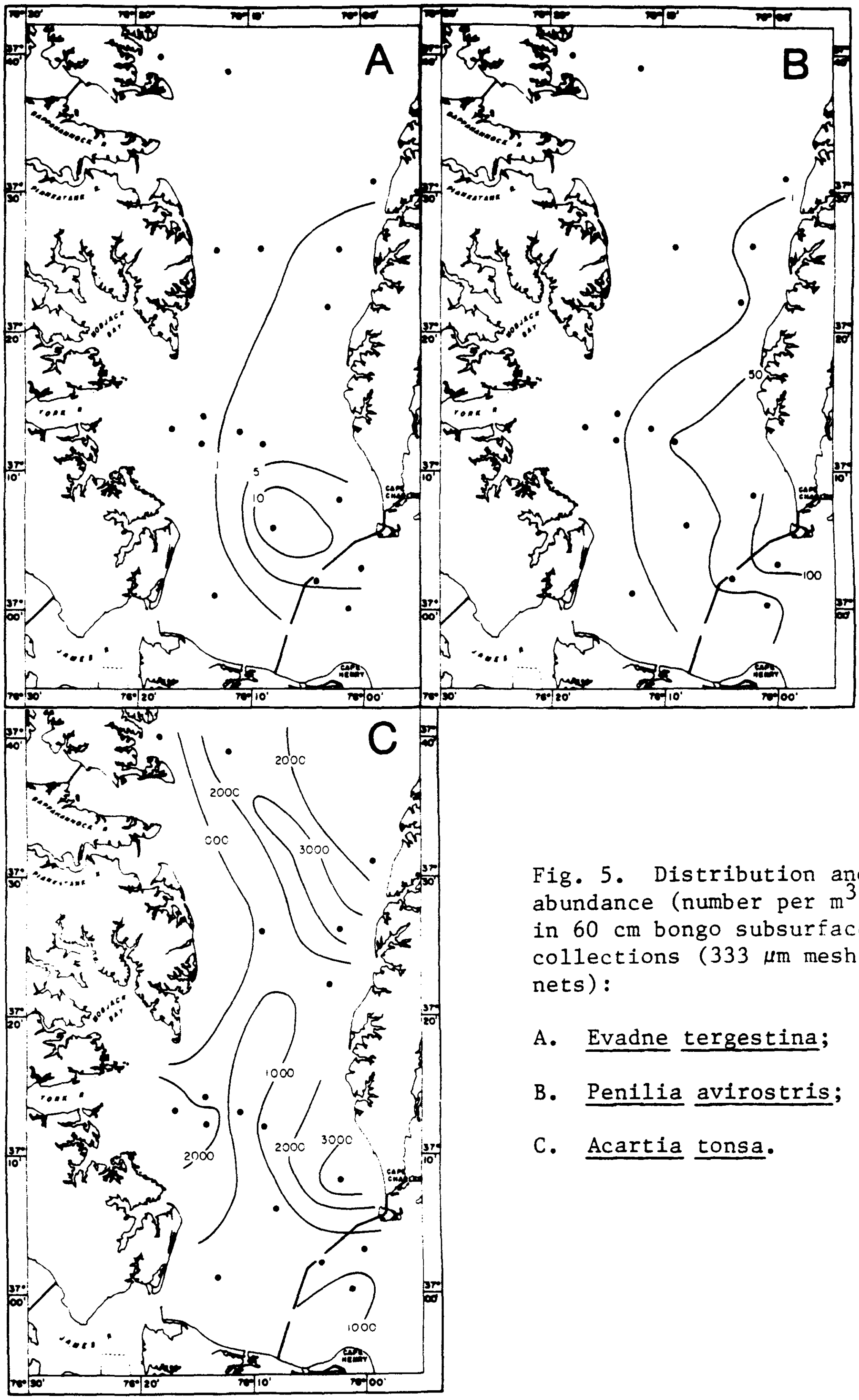

Fig. 5. Distribution and abundance (number per m^3) in 60 cm bongo subsurface collections (333 μm mesh nets):

A. Evadne tergestina;

B. Penilia avirostris;

C. Acartia tonsa.

in the channel areas of the lower Bay (Fig. 5C); density in the plotted collections from 60 cm, 333 μm mesh, bongo nets exceeded $3{,}000/m^3$ at two locations near the Eastern Shore. Pseudodiaptomus coronatus (Fig. 6A) was most abundant in night collections and at stations near the Eastern Shore. Labidocera aestiva (Fig. 6B) reached highest densities in channels near the Bay mouth. Parvocalanus crassirostris*, a small calanoid species that passes through 333 μm meshes, was restricted to eastern lower Bay stations and 202 μm mesh collections (Fig. 6C). Average and maximum densities for identified copepods are given in Table 8. It is apparent from these data that (1) 202 μm mesh nets provide considerably higher estimates of Acartia tonsa and Parvocalanus crassirostris than do 333 μm mesh nets, the first because of retention of smaller copepodid stages, the second because of the small size of adults, (2) some of the rarer species are captured only in the large-mouth 60 cm nets, but others are detected in 18.5 cm bongo collections because of the larger aliquots normally examined, and (3) maximum catches in neuston collections of Labidocera aestiva and Pseudodiaptomus coronatus (at night at stations C23 and H63, respectively) reflect diel migration of these species into the surface layer.

Cirripedia. Barnacle larvae were not identified to species. Station occurrence in Table 4 and density estimates in Table 9 include

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* Two name changes among the Copepoda are incorporated in this report: Parvocalanus crassirostris (= Paracalanus crassirostris), Centropages velificatus (= C. furcatus)

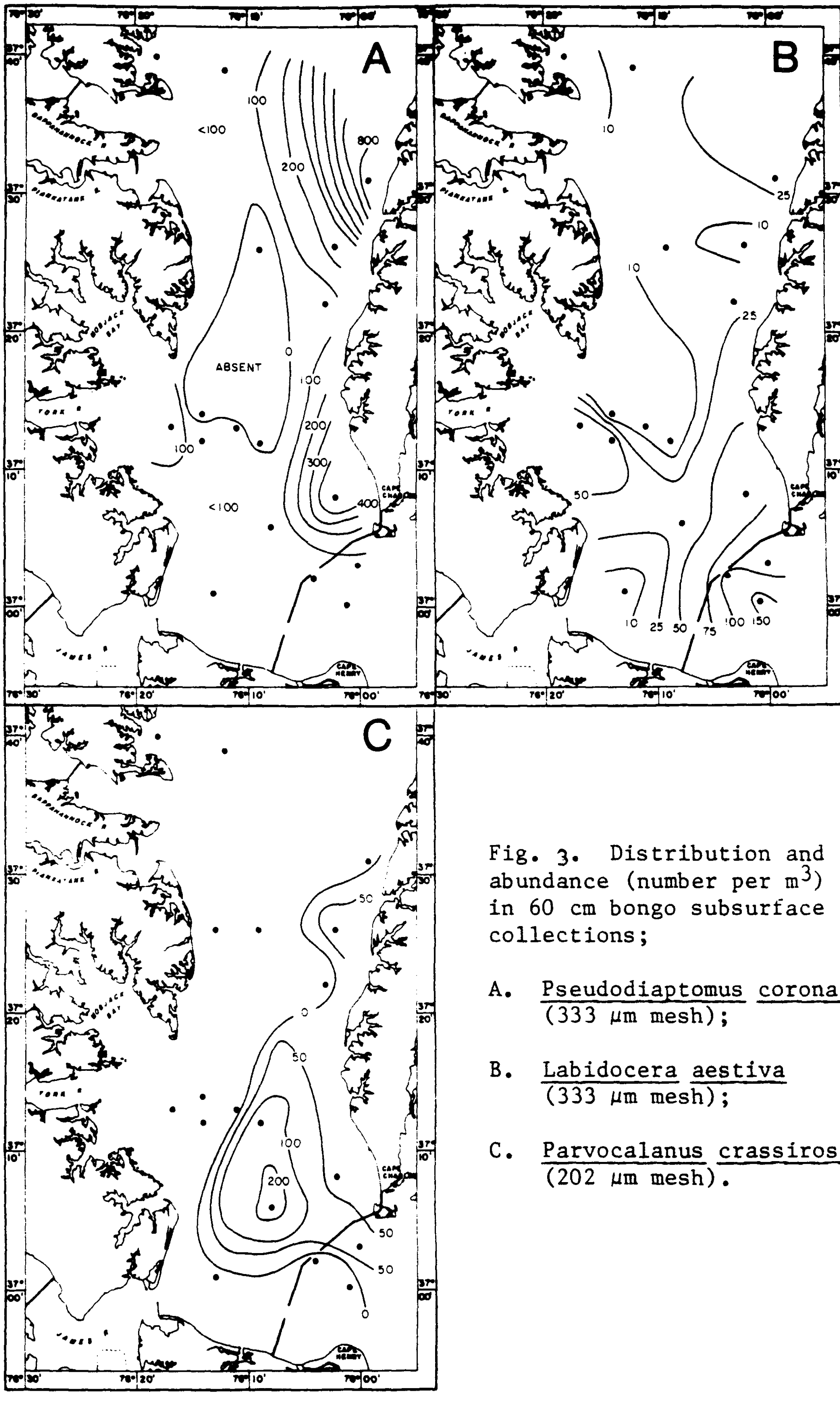


Fig. 3. Distribution and abundance (number per m^3) in 60 cm bongo subsurface collections;

A. Pseudodiaptomus coronatus (333 μm mesh);

B. Labidocera aestiva (333 μm mesh);

C. Parvocalanus crassirostris (202 μm mesh).

Table 8. Density estimates (numbers per m^3) for copepods in lower Chesapeake Bay, August 1978.

Taxa	Mean Density (No/m^3) N333	60B333	60B202	18.5B202	Maximum Density No/m^3	Station and net
Unidentified Calanoids	0.4	0	0	0	7.1	E48 N333
Acartia tonsa	1592.6	1575.5	12019.1	13700.8	41784	G163 18.5B202
Centropages hamatus	0	**	0.3	4.0	65	E48 18.5B202
Centropages typicus	0.7	0.5	0	2.0	47	C12 18.5B202
Centropages velificatus	1.2	0.7	1.4	4.5	122	B76 18.5B202
Eucalanus crassus	0	0.4	0	0	6.7	C23 60B333
Eucalanus pileatus	0	0.3	0	0	2.9	C30 60B333
Labidocera aestiva	75.0	34.8	85.0	41.3	441	C23 N333
Paracalanus indicus	0	0	0.3	0	5.7	C30 60B202
Paracalanus quasimodo	0.8	0.5	1.4	0.5	18.2	C12 60B202
Parvocalanus crassirostris	**	0	25.4	59.2	284	C12 18.5B202
Pseudodiaptomus coronatus	305.9	108.5	350.3	482.3	3247	H63 N333
Temora turbinata	*	1.0	0.3	4.0	60	G18 18.5B202
Euterpina acutifrons	0	0	0	4.0	59	G163 18.5B202
Unidentified cyclopoids	0	0	0	2.0	47	C12 18.5B202
Corycaeus speciosus	**	0.2	0.3	0	9.2	B76 60B202

Table 8. (continued)

Taxa	Mean Density (No/m^3) N333	60B333	60B202	18.5B202	Maximum Density No/m^3	Station and net
Oithona spp.	*	0.2	0.3	8.0	93	A37 18.5B202
Oncaea mediterranea	0	0	0	4.0	43	F10 18.5B202
Argulus alosae	**	*	*	*	0.2	D41 18.5B202
Caligus chelifer	0	*	0	0	**	C30 60B333

* less than $0.01/m^3$

** less than $0.1/m^3$

Table 9. Occurrence and calculated abundance of barnacle larvae (number per $100m^3$) in lower Chesapeake Bay, August 1978.

Station	Day or Night	Neuston 333 μm	60 cm Bongo 333 μm	60 cm Bongo 202 μm	18.5 cm Bongo 202 μm
D41	D	61	0	181	2,424
D48	N	3,940	32	798	766
E57	N	0	85	313	2,065
G159	N	1,314	--	659	598
H95	N	9	0	11	32
H63	N	3	5	116	324
G01	D	219	5	69	649
G18	D	9	0	170	70
G163	D	445	42	1,165	540
F10	D	9	17	31	17
E48	D	28	111	458	3,354
E69	D	118	74	163	787
A37	N	115	30	4,063	2,183
C12	N	42	41	1,708	204
B48	N	58	23	274	200
C23	N	4,874	0	410	524
B76	D	0	4	962	167
C30	D	0	33	45	98

both cyprid and naupliar stages. Although density estimates were generally higher in 202 μm mesh nets, the two highest estimates were from 333 μm mesh neuston collections. These occurred at station D48 (3,940/100 m^3 at 1933 EST) and station C23 (4,874/100 m^3 at 0355 h EST). Sharp increases in surface densities of barnacle larvae at dawn and dusk have previously been noted (Grant, 1977b, 1979).

Stomatopoda. The larvae of *Squilla empusa* were restricted to higher salinity stations (Table 4) in the lower Bay and along the Eastern Shore. Morgan (1980), in a study of *Squilla* larvae based partly on collections from an early (1971-1973) VIMS survey of lower Bay zooplankton, found these larvae to first appear in late July and to disappear from the plankton by mid-October. As in the present collections, *S. empusa* larvae were more prevalent in the eastern and channel areas of the lower Bay (Morgan, 1980).

Densities in August 1978 were well below those observed in 1971 and 1972 (Morgan, 1980) despite the use of larger, more efficient samplers (60 cm vs. 18.5 cm bongos) and the addition of neuston sampling. The maximum density observed in August 1978 was 0.36/m^3 in the neuston collection at station C23 (a night collection). Mean densities for the entire sampling area in 1971 and 1972 were 0.37/m^3 and 0.59/m^3, respectively. Similar estimates for August 1978 were 0.01/m^3 or less for each of the four net types.

Mysidacea. Three species of mysids occurred in August 1978 collections. The most abundant and ubiquitous of the three, *Neomysis americana*, appeared most abundantly at night (Table 10), apparently

Table 10. Density of *Neomysis americana* in day and night collections obtained with 60 cm bongo nets of 333 μm mesh, 23-25 August 1978.

Day Station	Hour (EST)	Density Number/m^3	Night Station	Hour (EST)	Density Number/m^3
B76	0530	4.06	D48	1933	173
C30	0720	3.98	E57	2030	144
G01	0730	0.07	A37	2155	48.4
G18	0845	0.19	C12	2400	51.1
G163	1100	0.06	B48	0130	35.4
F10	1340	0.05	H95	0240	169
E48	1640	0.03	H63	0330	13.3
E69	1740	0.00	C23	0335	216
D41	1820	0.70			

spending daylight hours on, or very close to, the bottom. Density in 60 cm, 333 μm mesh, bongo nets (oblique tows) ranged from 0 to $4.06/m^3$ in daytime collections, from 13.3 to $216/m^3$ in night collections.

Metamysidopsis mexicana (Table 11) also occurred most abundantly at night, and in all four types of nets. Density in two night neuston collections near the Bay mouth exceeded $100/m^3$. The general absence of this species from daytime collections could explain the lack of previous records of its occurrence from the lower Chesapeake Bay. The 1971-1973 VIMS survey, for example, was conducted entirely in daylight hours and without benefit of neuston nets. The species has been reported as *Metamysidopsis munda* (see Bacescu, 1969 for name change to *M. mexicana*) from Indian River Inlet, Delaware (Hopkins, 1965) and the Gulf of Mexico to Chesapeake Bay (Tattersall, 1951). Williams (1972) reported *M. mexicana* from North Carolina inlets.

Mean densities for the above two species and for *Mysidopsis bigelowi*, the least abundant of the three mysids, are given in Table 12. Abundance of *Neomysis americana* was approximately one order of magnitude higher than in March (Grant and Olney, 1979); mean densities of *M. bigleowi* were about equal to maximum densities in March.

Cumacea. These primarily benthic crustaceans occurred least frequently in neuston collections and in the small-mouthed 18.5 cm bongo collections. Among the four species collected (see Table 4), only *Oxyurostylis smithi* attained densities of $0.01/m^3$ (202 μm, 60 cm bongo collections). Except for two individuals, cumaceans were restricted to night collections. *O. smithi* was the most frequent and

Table 11. Occurrence and calculated abundance (number per $100m^3$) of *Metamysidopsis mexicana* in lower Chesapeake Bay, August 1978.

Station	Day or Night	Neuston 333 μm	60 cm Bongo 333 μm	60 cm Bongo 202 μm	18.5 cm Bongo 202 μm
D41	D	0	0	0	30
D48	N	0	0	47	43
E57	N	0	0	0	0
G159	N	0	--	0	0
H95	N	950	112	110	0
H63	N	189	434	386	216
G01	D	0	2	0	0
G18	D	0	4	0	0
G163	D	0	0	0	0
F10	D	0	1	0	0
E48	D	0	0	0	0
E69	D	0	1	0	0
A37	N	0	81	0	0
C12	N	211	0	0	0
B48	N	10,368	207	360	246
C23	N	10,172	0	759	381
B76	D	27	7	460	452
C30	D	0	5	0	12

Table 12. Density estimates (numbers per m^3) for mysids in lower Chesapeake Bay, August 1978.

Species	Mean Density (No/m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/m^3	Station and net
Neomysis americana	19.8	44.0	45.5	58.5	425	A37 18.5B202
Metamysidopsis mexicana	10.7	0.5	0.8	0.5	104	B48 N33
Mysidopsis bigelowi	0.9	0.7	0.4	0.7	11	D48 N333

widely distributed of the cumaceans, as in March 1978 (Grant and Olney, 1979).

Isopoda. Among the six named species of isopods collected in August 1978, at least one of the two more widely distributed taxa, _Aegathoa medialis_ and _Aegathoa oculata_, may in fact represent young stages in the development of _Lironeca ovalis_ (Sandifer and Kerby, in press). However, since both of the earlier described species of _Aegathoa_ were present in these Chesapeake Bay collections, we have retained the older terminology. _A. oculata_ occurred at 14 of the 18 sampled stations, and _A. medialis_ co-occurred at six of those stations. Other species (_Edotea triloba_, _Lironeca ovalis_, _Sphaeroma quadridentatum_, _Idotea baltica_) occurred at 6, 5, 3 and 2 stations, respectively. Mean densities (per 100 m^3 in Table 13) were low, with a maximum of 20/100 m^3 recorded for _A. oculata_ in neuston tows. This species apparently rises to the surface at night. Other species with neustonic habits include _Sphaeroma quadridentatum_ found only in neuston collections and _Idotea baltica_, with 18 of the 19 collected individuals captured in neuston nets.

Amphipoda. Twenty-one species of amphipods (Table 4) were identified in August collections, an increase of 10 species compared with the March 1978 survey. Collections in all nets except the small bongo, which is generally inefficient for the capture of amphipods, were dominated by the species _Gammarus mucronatus_. This species was particularly abundant in night neuston collections and appears to congregate in the surface layer at night. Maximum observed density

Table 13. Density estimates (numbers per 100 m^3) for isopods in lower Chesapeake Bay, August 1978.

Species	Mean Density (No/100 m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/m^3	Station and net
Aegathoa oculata	20.0	0.6	4.4	0.8	162.2	G159 N333
Aegathoa medialis	<0.1	0.1	0.3	0.8	18.2	A37 18.5B202
Edotea triloba	<0.1	0.1	3.3	3.1	52.7	G159 60B202
Idotea baltica	1.6	0	<0.1	0	22.9	H63 N333
Lironeca ovalis	0.7	0	0.2	0	6.2	G159 N333
Sphaeroma quadridentatum	0.3	0	0	0	2.1	G159 N333
Unidentified isopods	0	0	0.3	0.8	15.4	B48 18.5B202

(over 4,000 per 100 m^3) occurred at station H63 in a neuston collection (see Table 14). *G. mucronatus* was also frequent in March collections (Grant and Olney, 1979). Other amphipods that appear in higher average densities in the surface layer include the *Ampithoe* spp., *Microprotopus raneyi* and immature stages of *Melita* sp. Ampeliscids, on the other hand, appeared to avoid surface waters.

Decapoda. An abundance of the larvae of diverse shrimps and crabs represents one of the most dramatic differences between summer and winter plankton in Chesapeake Bay. In winter and early spring (Grant and Olney, 1979), the sand shrimp, *Crangon septemspinosa*, is the single reproducing decapod crustacean; in August 1978, at least 31 species were present in the plankton (Table 4). Unlike several other groups of crustaceans, many of the decapods were widely distributed within the sampling area; seven occurred at every station. These seven species were also among the most abundant, as shown in Table 15. *Uca* sp. and *Hexapanopeus angustifrons* were the most abundant of the decapod larvae, both with maximum observed densities exceeding 350/m^3. These species were particularly abundant in night neuston collections, demonstrated for *Uca* sp. in Table 16. Diurnal migration is further suggested by the relatively higher abundance in subsurface tows in the daytime, compared with neuston collections. The data for densities at individual stations (not shown) also strongly suggested diurnal migration by larvae of *Callinectes* sp., *Palaemonetes* sp., *Pinnixa sayana* and *Pinnotheres maculatus*. Absence in, or apparent avoidance of, the surface layer occurred with larvae of *Callianassa biformis*, *Pagurus longicarpus*, *Neopanope sayi*, *Ovalipes ocellatus* and

Table 14. Density estimates (numbers per 100 m^3) for the most frequent and abundant amphipods in lower Chesapeake Bay, August 1978.

Species	Mean Density (No/100 m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/m^3	Station and net
Gammarus mucronatus	376.9	54.4	6.9	1.6	4145.7	H63 N333
Unidentified gammarids	22.3	0.1	<0.1	0	345.5	H63 N333
Lestrigonus bengalensis	0.6	0.3	4.1	1.6	44.4	C30 60B202
Ampelisca abdita	0	2.0	0.3	0	45.8	C12 60B202
Ampelisca vadorum	0	0.6	2.0	3.9	92.5	C12 18.5B202
Ampithoe longimana	6.0	0.4	0.2	0.8	52.4	E57 N333
Ampithoe valida	5.7	0.1	0	0	86.4	H63 N333
Corophium lacustre	0.3	0.5	1.0	0.8	11.5	G163 18.5B202
Microprotopus raneyi	1.5	0.2	0.1	0	14.8	H95 N333
Melita sp.	9.0	0	0.3	0	197.1	G159 N333

Table 15. Density estimates (numbers per m^3) for the most frequent and abundant decapod crustacean larvae in lower Chesapeake Bay plankton, August 1978.

Taxa	Mean Density (No/m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/m^3	Station and net
Uca sp.	18.10	4.55	5.23	6.14	373.6	C23 N333
Hexapanopeus angustifrons	13.48	4.27	2.73	19.00	364.7	C23 N333
Upogebia affinis	1.31	1.34	0.99	3.51	72.4	C23 18.5B202
Callianassa biformis	0.25	1.34	1.68	2.22	22.9	B76 18.5B202
Callinectes sp.	1.76	0.80	1.60	1.20	42.4	C23 N333
Pagurus longicarpus	0.28	0.58	0.68	2.11	37.1	C23 18.5B202
Pinnixa chaetopterana	2.54	0.45	2.80	2.05	93.2	C23 N333
Libinia sp.	0.33	0.35	0.31	0.95	8.1	E48 18.5B202
Neopanope sayi	0.14	0.33	0.68	2.01	28.4	E48 18.5B202
Pinnixa sayana	0.49	0.25	0.35	0.38	8.5	C23 N333
Palaemonetes sp.	1.99	0.25	0.24	0.19	5.9	H63 N333
Unid. pinnotherid	0.46	0.22	0.15	0.35	8.5	C23 N333
Panopeus herbstii	**	0.18	**	0.39	3.9	C23 18.5B202
Ovalipes ocellatus	0	0.17	0.35	0.82	22.9	B76 18.5B202
Pinnotheres ostreum	1.21	0.15	0.78	**	42.2	C23 N333
Pinnotheres maculatus	0.55	0.15	0.19	0.40	7.4	D48 N333
Alpheus normanni	**	0.14	0.12	**	1.1	H95 60B333
Crangon septemspinosa	0.75	0.13	0.19	0.42	12.5	G159 N333

Table 15. (continued)

Taxa	Mean Density (No/m^3) N333	60B333	60B202	18.5B202	Maximum Density No/m^3	Station and net
Euceramus praelongus	0.22	0.12	**	**	8.5	C23 N333
Callianassa atlantica	0	0.10	**	**	2.2	C23 60B333
Ogyrides limicola	**	**	**	0.17	2.1	D41 18.5B202
Lucifer faxoni	0.28	**	**	**	9.6	C23 N333

** less than $0.1/m^3$

Table 16. Occurrence and abundance (number per $100 m^3$) of *Uca* sp. larvae in the lower Chesapeake Bay, August 1978.

Station	Day or Night	Neuston 333 μm	60 cm Bongo 333 μm	60 cm Bongo 202 μm	18.5 cm Bongo 202 μm
D41	D	2	23	24	91
D48	N	4,428	72	211	43
E57	N	79	110	50	522
G159	N	723	--	26	33
H95	N	2,019	1,119	1,103	32
H63	N	2,677	271	1,005	54
G01	D	86	40	14	41
G18	D	4	141	58	174
G163	D	0	29	42	80
F10	D	2	154	76	85
E48	D	15	85	69	810
E69	D	14	0	26	90
A37	N	194	8	307	91
C12	N	335	0	114	56
B48	N	3,976	703	101	354
C23	N	37,364	4,042	1,844	4,190
B76	D	407	2,348	4,998	7,619
C30	D	37	1,527	1,563	2,341

Callianassa atlantica. Many of the rarer species were collected only in the larger subsurface nets (60 cm mouth opening).

Comparisons of densities betwen March and August collections are limited to Crangon septemspinosa and Palaemonetes sp., the only two decapods occurring in March. Maximum observed density of C. septemspinosa was 158/m^3 in March, but only 5.9/m^3 in August. Maximum density of Palaemonetes sp., on the other hand, remained similar (3 and 5.9/m^3 in March and August, respectively).

The larvae of fiddler crabs (Uca spp.) were also the most abundant taxon of decapod crustacean larvae in an earlier study of the York River and lower Chesapeake Bay (Sandifer, 1972). On a year-round basis, Goy (1976) ranked them as tenth in abundance, with maximum abundance occurring in July or August.

Larvae of Hexapanopeus angustifrons, the narrow mud crab, were co-dominants in our August collections, and found in highest numbers (Fig. 7A) near the bay mouth and in channel locations. It was also one of the most abundant species found in the studies of Sandifer (1972) and Goy (1976), with a peak in August. Upogebia affinis (Fig. 7B) and Callianassa biformis larvae were equally abundant in 60 cm 333 μm nets with a mean density of 1.34/m^3. U. affinis was ranked second in abundance both in summer and year-round by Goy (1976). Both species are abundant near the mouth of the Bay.

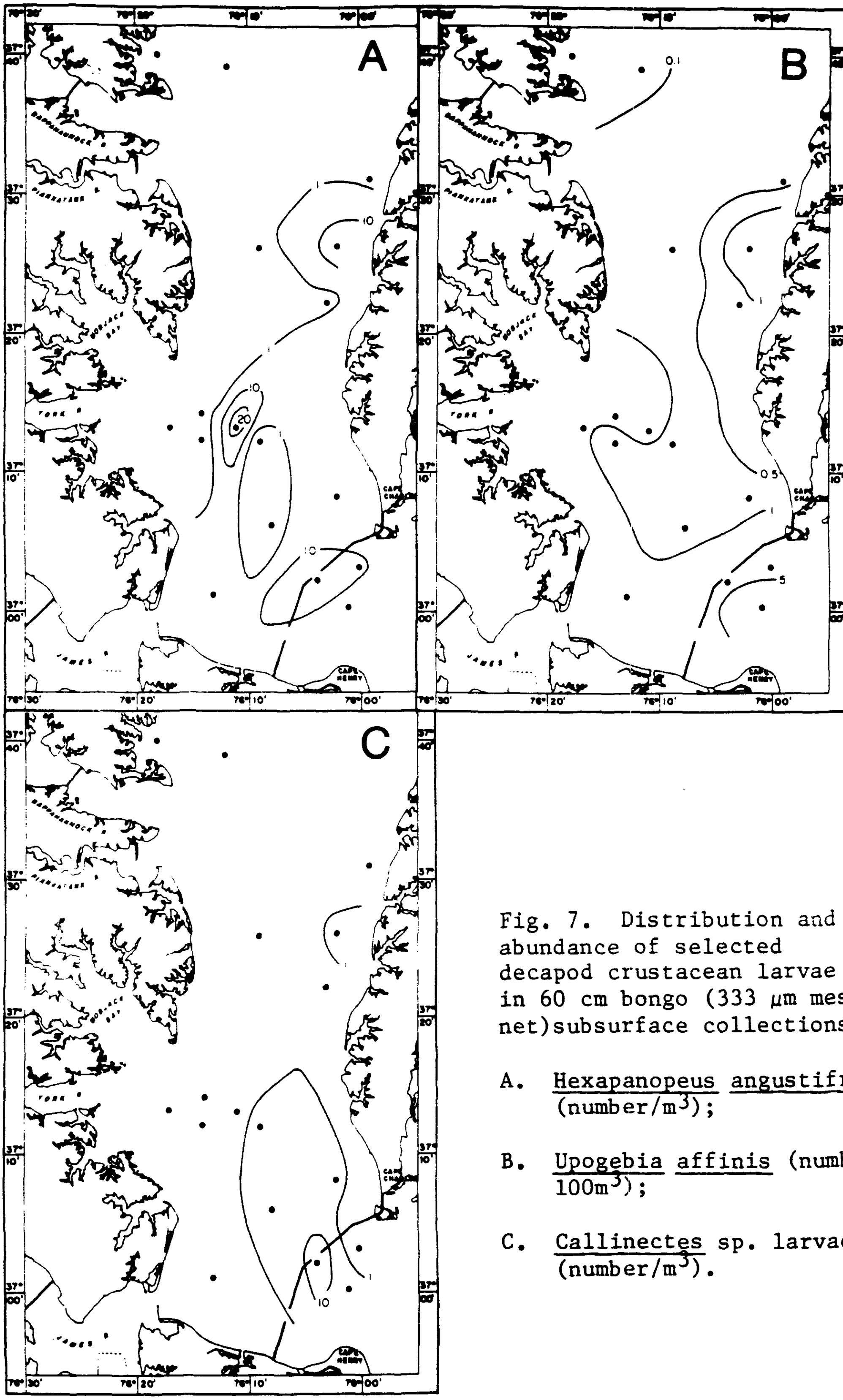


Fig. 7. Distribution and abundance of selected decapod crustacean larvae in 60 cm bongo (333 μm mesh net)subsurface collections:

A. Hexapanopeus angustifrons (number/m^3);

B. Upogebia affinis (number/ 100m^3);

C. Callinectes sp. larvae (number/m^3).

Larvae of the blue crab, Callinectes sp.*, ranked as the fifth most abundant decapod in three of our four net types (the larger neuston and 60 cm bongos). Goy (1976) noted Callinectes as the dominant summer larva in collections from 1972 and 1973, with a reduction in its abundance in 1975. In the present collections megalopae comprised a large portion of total catches in subsurface nets (30.2-84.2%), in contrast to only 6.9% of larvae in surface neuston collections. This difference in depth distribution of developmental stages may reflect a behavioral adaptation of the species that aids in recruitment of populations to the estuary. Most larvae occurred near the Bay mouth (Fig. 7C).

Larvae of the parchment worm crab, Pinnixa chaetopterana, ranked high in abundance (3rd and 2nd, respectively) in neuston and 60 cm bongo 202 μm mesh nets. This species was among the list of summer dominants presented by Goy (1976). Goy (1976) also listed the porcellanids, Euceramus praelongus and Polyonyx gibbesi, as bay mouth contributors to summer dominants. These were reduced (Euceramus) or absent (Polyonyx) in August 1978 collections.

Phoronida. Higher salinity stations near the Bay mouth and along the Eastern Shore were populated with large numbers of the actinotroch larvae of phoronids. These are small forms, so were caught mostly in our 202 μm mesh nets (Fig. 8A). There are two species of phoronids

* Larvae are conservatively referred to as Callinectes sp. in this report because of the possibility of the inclusion of some C. similis

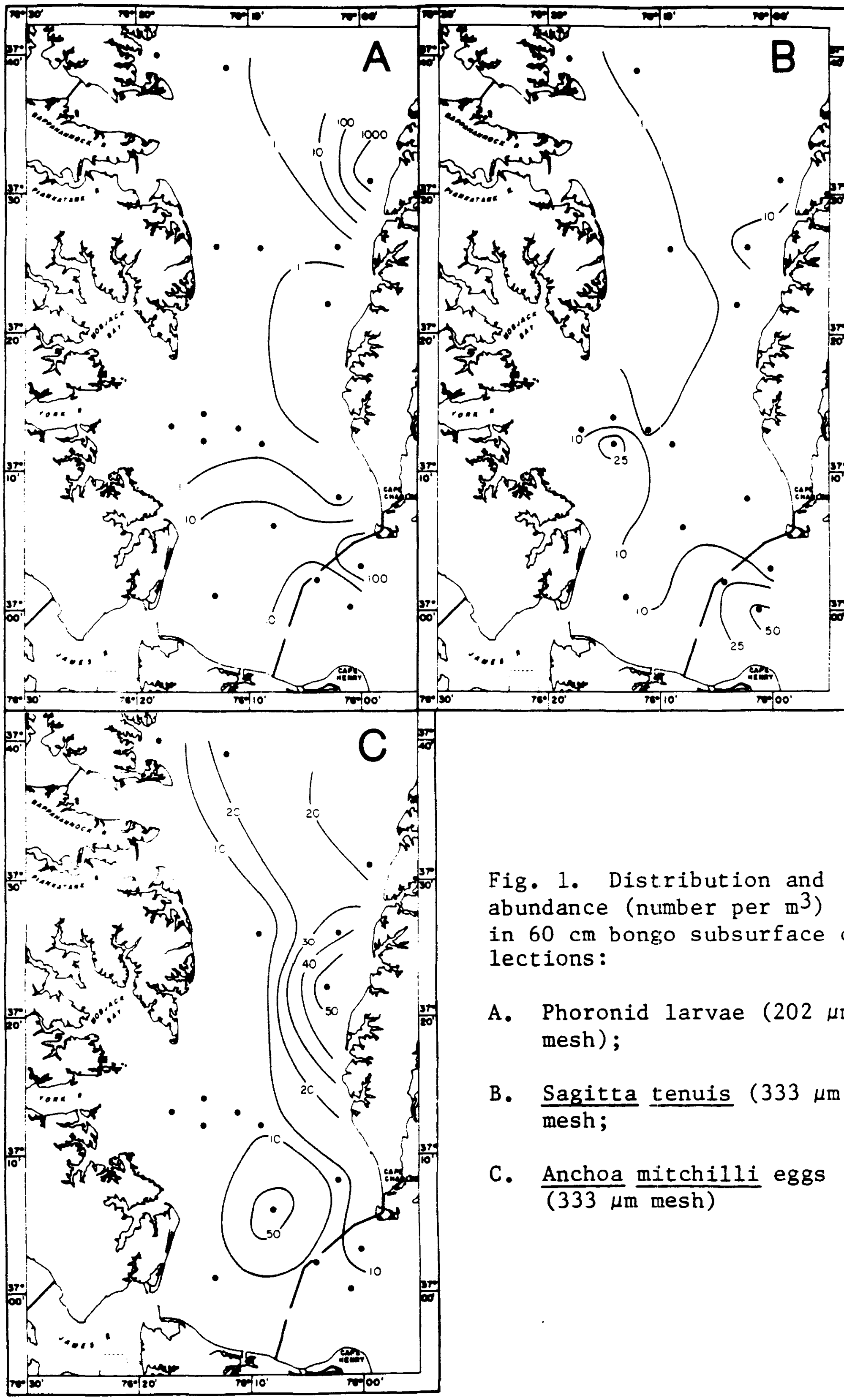


Fig. 1. Distribution and abundance (number per m^3) in 60 cm bongo subsurface collections:

A. Phoronid larvae (202 μm mesh);

B. Sagitta tenuis (333 μm mesh;

C. Anchoa mitchilli eggs (333 μm mesh) common to the lower Chesapeake Bay: Phoronis psammophila and P. muelleri (personal communication, Thomas J. Fredette), found respectively in muddy and sandy environments. These larvae could belong to either or both species. They were present at every station sampled, but abundant only at station H63 (where maximum density of $1076/m^3$ occurred) and in the lower tier of bay mouth stations. Mean abundance at all stations in 60 cm 202 μm collections was $74.5/m^3$.

Chaetognatha. Three species of chaetognaths typically occur in the lower Chesapeake Bay during summer and fall months (Grant, 1977a). All three (Sagitta tenuis, S. hispida, S. enflata) were found in August 1978 collections (Table 17). The proportional catch of the three species, based on a total of 27,289 chaetognaths, (a ratio of 4969 S. tenuis: 30 S. hispida: 1 S. enflata) confirms previous observations on the predominance of S. tenuis in summer collections. Grant (1977a) found that S. tenuis comprised nearly 99% of the total chaetognath population in lower Chesapeake Bay over a 24-month period. The present collections were also heavily predominated (99.38%) by S. tenuis.

Mean densities of the three species in collections from the four net types (Table 17) are considerably different, especially densities in neuston nets compared with those from subsurface collections. Sagitta tenuis and S. hispida occurred in the surface layer almost exclusively at night. Only a small proportion (1.2%) of the total catch of S. tenuis occurred in surface waters, but 56.7% of the S. hispida catch occurred in night neuston collections. Density of S.

Table 17. Density of chaetognaths (numbers per 100 m^3) in lower Chesapeake Bay, August 1978.

Species	Mean Density (No/100 m^3)				Maximum Density	
	N333	60B333	60B202	18.5B202	No/100m^3	Station and net
Sagitta tenuis	27.6	964.4	781.1	1209.2	5090.9	C30 60B333
Sagitta hispida	8.1	2.7	2.1	0.8	171.9	D48 N333
Sagitta enflata	0	0.3	0.1	0	5.6	E69 60B333

tenuis in the present collections decreased from a peak at the Bay mouth (Fig. 8B). Mean overall density in August 1978 varied from $7.8/m^3$ in 60 cm, 202 μm mesh nets to $12.1/m^3$ in 18.5 cm, 202 μm mesh, nets. Mean density of 60 cm 333 μm mesh collections was $9.6/m^3$. Collections in August 1971 and 1972 with the 18.5 cm, 202 m net yielded slightly higher estimates of density: $18.1/m^3$ and $12.75/m^3$, respectively (Grant, 1977a). Peak seasonal densities were found, in this earlier study, to occur in September. Subsurface densities of *S. hispida* in the present collections (0.8-2.7/100 m^3) were considerably lower than estimates from August 1971 and 1972 (11.7 and 3.7/100 m^3, respectively).

Sagitta enflata is always quite rare in Chesapeake Bay in summer months; it increases in abundance with falling temperatures and increased salinity of fall months, reaching peak abundance in November (Grant, 1977a).

Tunicata. Two species of pelagic tunicates were limited to a few stations in the Bay mouth and lower Bay channels. The appendicularian, *Oikopleura* sp., was found at stations E48, C12, C23 and B76, in maximum density of $33.7/m^3$ (Sta. C23, 60 cm bongo 333 μm mesh net). Only five specimens of *Dolioletta gegenbauri* were taken at Sta. E48 ($< 1/m^3$).

Pisces. Widely-distributed fish eggs and larvae in August 1978 included *Anchoa mitchilli* eggs and *Anchoa* sp. larvae, found at every station; sciaenid eggs, and larvae of atherinids and *Gobiosoma* sp. were collected at all but one or two stations (Table 4). Except for sciaenids, represented here by eggs, these are all important forage fishes in the lower Chesapeake Bay, and as would be expected from their position in the food chain, among the most abundant species. Bay anchovy eggs (Table 18 and Fig. 8C) were most abundant, especially along the Eastern Shore and in the lower channel of the Bay, where a maximum density of $136/m^3$ (18.5 cm, 202 μm bongo net) was observed. *Anchoa* sp. larvae (Fig. 9A) were similarly distributed, except for relatively high abundance at a station off the mouth of the James River and a reversal of relative abundance in surface vs. subsurface waters (Table 18). While *A. mitchilli* eggs were more abundant in neuston collections than in any of the subsurface collections, *Anchoa* sp. larvae were only 1/10 as abundant in the surface layer as they were in deeper collections.

Olney (1978) reported mean densities of approximately 33, 45 and 143 *A. mitchilli* eggs/m^3 in the months of August 1971, 1972 and 1973, respectively, using 18.5 cm, 202 μm mesh bongo nets in daylight. All of thse estimates exceeded our present estiamtes for abundance in 1978. Similarly, *A. mitchilli* larvae were about an order of magnitude more abundant in August of 1971, 1972 and 1973 (approx. mean abundance of 22, 17 and 23 larvae/m^3, respectively).

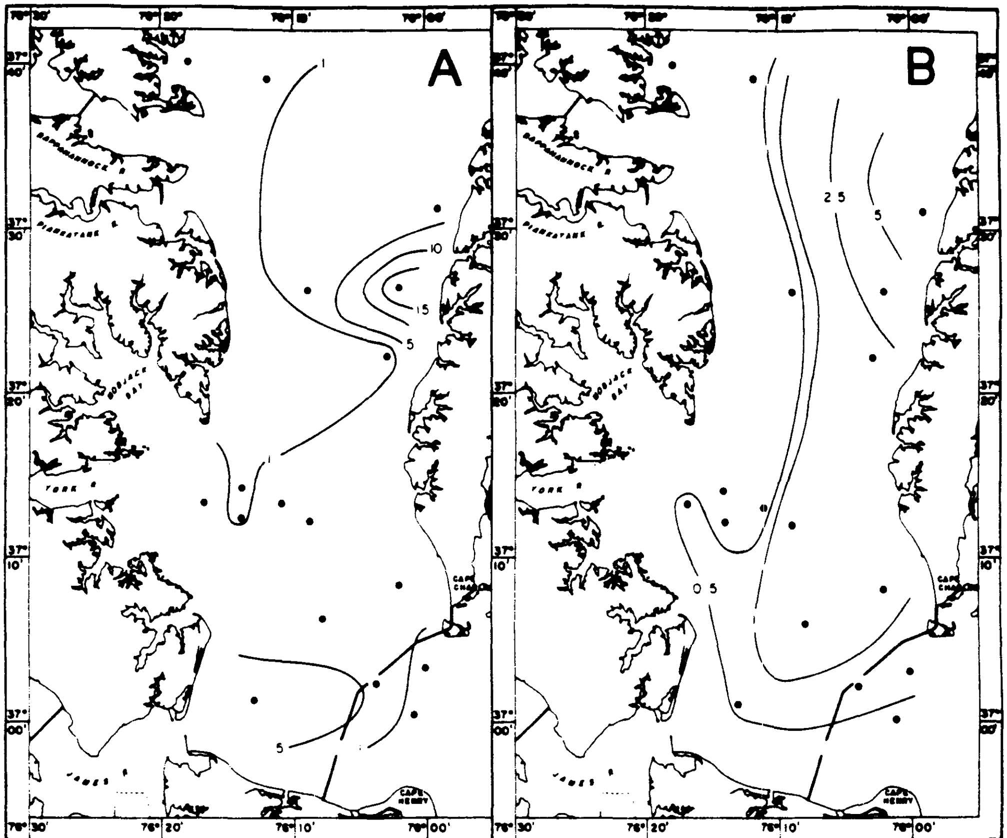
Other abundant eggs in August 1978 collections included those of the family Sciaenidae (likely *Cynoscion regalis* for the most part) and *Trinectes maculatus*, the hogchoker. Surface density of the former, highly buoyant, eggs were twice that in subsurface collections (Table 18), but *T. maculatus* eggs appeared in greatest density lower in the

Table 18. Density of the most common ichthyoplankton in lower Chesapeake Bay, August 1978 (number per 100 m^3).

Species	Mean Density (No/100 m^3) N333	60B333	60B202	18.5B202	Maximum Density No/100m^3	Station and net	
Anchoa mitchilli eggs	2169.6	1503.1	1164.0	1518.7	13629.6	C12	18.5B202
Anchoa sp. larvae	25.7	297.7	264.1	312.6	1902.1	H95	60B333
Sciaenid eggs	216.7	118.3	90.8	90.2	2245.6	H63	N333
Trinectes maculatus eggs	7.6	29.2	26.7	23.3	288.3	E57	60B333
Gobiosoma sp.	13.5	17.8	31.9	48.2	709.1	A37	18.5B202
G. ginsburgi	0	?11.0	1.2	0	?111.9	H95	60B333
Atherinid larvae	16.0	?9.2	1.7	0	?119.9	H95	60B333
Membras martinica	159.4	7.9	12.5	0	1338.4	A37	N333
A. mitchilli post-larvae, juveniles & adults	0.5	4.6	19.7	6.2	195.2	A37	60B202
Prionotus sp.	0.6	3.0	2.8	3.1	95.2	C23	18.5B202
Cynoscion regalis	0.3	2.4	6.6	8.6	142.9	C23	18.5B202
Peprilus triacanthus	**	1.4	0.8	0.8	?15.4	B48	18.5B202
Etropus microstomus	**	0.8	2.4	0.8	38.8	C30	60B202
Syngnathus fuscus	1.1	0.7	0.5	1.6	14.4	G159	N333
Symphurus plagiusa eggs	0	0.6	2.2	8.6	95.2	C23	18.5B202
S. plagiusa larvae	0	0.5	0.5	0	5.7	C30	60B333
Hypsoblennius hentzi	3.6	0.4	0.4	0	35.6	D48	N333
T. maculatus larvae	**	0.4	1.6	1.6	?19.2	A37	60B202
Centropristes striata	0	0.4	0.5	0.8	16.9	C23	60B202
Rissola marginata	0	0.3	2.9	0	43.3	C30	60B202

** less than 0.1/100 m^3

? Weighted by single specimen in sampled aliquot



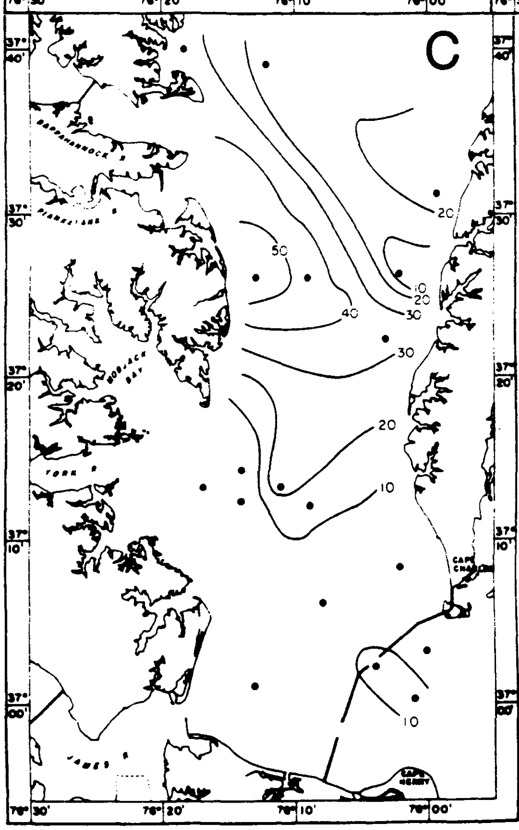


Fig. 2. Distribution and abundance of

A. Anchoa sp. larvae (60 cm bongo 333 nets, subsurface, number/m^3);

B. Sciaenid eggs (60 cm bongo 333 nets, subsurface, number/m^3);

C. Atherinid larvae (1 meter neuston 333 nets, surface, number/$100m^3$.

water column. Sciaenid eggs decreased in density to the west and southwest from maximum abundance at Station H63, near the Eastern Shore (Fig. 9B). Trinectes maculatus eggs, on the other hand, were more abundant in mid-Bay channel locations, especially off the mouth of the York River (stations E57 and E69).

Sciaenid and T. maculatus eggs were also dominant summer components of ichthyoplankton in the early 1970's collections identified by Olney (1978). Abundances (in no./m^3) as in anchovies, were generally much higher:

	T. maculatus		Sciaenidae		
	$\bar{x}$	max.	$\bar{x}$	max.	Source
August 1971	5.9	19.6	8.2	67.6	Olney (1978)
August 1972	3.8	34.1	2.4	10.3	Olney (1978)
August 1973	2.0	9.6	2.5	10.9	Olney (1978)
August 1975	0.01	0.28	1.7	25.1	Olney (1978)
August 1978	0.23	2.9	0.90	22.5	Present Study

Adults of the rough silverside, Membras martinica, were prominent components of night neuston collections, but genrally absent in daytime surface collections, as also noted by Olney (1978) in neuston collections taken in August 1975. Densities in surface tows (mean of 159/100m^3, Table 18) were an order of magnitude higher than mean densities in subsurface collections. Atherinid larvae (not separable into Menidia and Membras) were also abundant in neuston tows, day or night, and in lower salinity portions of the study area (Fig. 9C). Another species that appeared to favor the surface layer (Table 18) was the feather blenny, Hypsoblennius hentzi. Most of the taxa not referred to above were more abundant in subsurface collections than in the neuston.

Community Analysis

The structure of lower Bay zooplankton communities in August 1978 was examined in terms of frequency of occurrence and rank of abundance among species, diversity of collections, species dominance, and similarity of collections and species distribution (normal and inverse cluster analyses). Some analyses were limited to neuston and 60 cm, 333 μm mesh collections.

Frequency of Occurrence and Relative Abundance. The most frequently occurring taxa from neuston (333 μm) and 60 cm bongo 333 μm collections are listed in Tables 19 and 20. Average and maximum densities in each of the selected net types are also provided. Lower Bay averages are based on total numbers of collected individuals and total volume of water sampled (1,153.4 m^3 for neuston and 1,407.9 m^3 for 60 cm 333 μm collections).

As shown in results of our March 1978 survey (Grant and Olney, 1979), occurrence of species is more sporadic in neuston collections than in subsurface collections. The 22 taxa listed for subsurface collections occurred in at least 70% of the collections, while only 15 of the 22 taxa in the neuston list were that frequent. Densities of the dominant *Acartia tonsa* were remarkably similar in surface and subsurface nets (Tables 19 and 20); other species, except two molluscs, *Mulinia lateralis* and *Nassarius vibex*, differed greatly in abundance in the two nets. Common subsurface taxa absent from the list of most common ones in neuston collections included *Gobiosoma* sp larvae, sciaenid eggs, *Chrysaoura quinquecirrha*, and larvae of the

Table 19. Frequency of occurrence and calculated density of the most common zooplankton species in surface collections (333 m mesh neuston net), August 1978.

Species	Percent Occurrence	Density (number/100 m^3) Lower Bay Average	Maximum
Acartia tonsa	100.0	158,911	1,079,090
Eggs of *Anchoa mitchilli*	100.0	2,170	8,905
Uca sp.	94.4	4,390	42,839
Labidocera aestiva	88.9	7,504	44,079
Hexapanopeus augustifrons	88.9	1,348	36,347
Neomysis americana	88.9	1,115	27,908
Atherinid larvae	88.9	17	60
Barnacle larvae	83.3	417	4,874
Pseudodiaptomus coronatus	77.8	30,842	324,750
Callinectes sp.	77.8	176	4,242
Anchoa sp. larvae	77.8	17	131
Palaemonetes sp.	77.2	268	1,771
Mulinia lateralis	77.2	127	1,296
Gammarus mucronatus	72.2	115	1,708
Unid. gastropods	72.2	98	788
Evadne tergestina	66.7	381	2,036
Sagitta tenuis	66.7	71	1,695
Aegathoa oculata	66.7	20	162
Nassarius vibex	61.1	40	629
Hypsoblennius hentzi	55.6	3	36
Penilia avirostris	50.0	1,567	32,212
Membras martinica	50.0	161	1,338

Table 20. Frequency of occurrence and calculated density of the most common zooplankton species in subsurface, oblique collections obtained with a 60 cm bongo sampler equipped with 333 μm mesh nets.

Species	Percent Occurrence	Density (number/100 m^3) Lower Bay Average	Maximum
Acartia tonsa	100.0	157,566	340,140
Sagitta tenuis	100.0	958	5,091
Hexapanopeus angustifrons	100.0	434	2,331
Upogebia affinis	100.0	143	764
Neomysis americana	94.1	4,676	21,565
Anchoa mitchilli eggs	94.1	1,410	6,302
Anchoa sp. larvae	94.1	313	1,902
Pseudodiaptomus coronatus	88.2	10,851	83,759
Uca sp.	88.2	453	4,042
Mulinia lateralis	88.2	114	532
Callinectes sp.	88.2	81	1,123
Gobiosoma sp. larvae	88.2	25	262
Labidocera aestiva	88.2	3,482	15,418
Unid. gastropods	82.4	643	2,994
Evadne tergestina	76.5	226	1,847
Sciaenid eggs	76.5	121	738
Pagurus longicarpus	76.5	59	327
Nassarius vibex	76.5	48	196
Barnacle larvae	76.5	24	111
Pinnixa chaetopterana	70.6	45	449
Libinia sp.	70.6	35	112
Chrysaoura quinquecirrha	70.6	3.4	13

decapod crustaceans _Upogebia affinis_, _Pagurus longicarpus_, _Pinnixa chaetopterana_ and _Libinia_ sp. The chaetognath _Sagitta tenuis_ and _Anchoa_ sp. larvae were at least an order of magnitude more abundant in subsurface collections.

Most common surface taxa absent from the list of frequent subsurface taxa included the amphipod _Gammarus mucronatus_, the isopod _Aegathoa oculata_, the cladoceran _Penilia avirostris_, the decapod crustacean larvae of _Palaemonetes_ sp., _Membras martinica_ and its probable larvae designated as "atherinid larvae," and larvae of _Hypsoblennius hentzi_. _Uca_ sp. and barnacle larvae were an order of magnitude more abundant in neuston collections. A preference for the surface layer in both _G. mucronatus_ and barnacle larvae was previously noted in winter-spring collections (Grant and Olney, 1979).

Dominant Species. The most characteristic feature of summer 1978 zooplankton collections was the overwhelming dominance of _Acartia tonsa_ (Table 21). This copepod was the numerically dominant species in every collection, irrespective of net type or mesh size. The most important subdominant species were _Pseudodiaptomus coronatus_, ranked second in abundance in 37 collections, _Labidocera aestiva_, second or third in 22 collections, _Neomysis americana_, _Anchoa mitchilli_ eggs, _Penilia avirostris_, unidentified gastropods and _Parvocalanus crassirostris_. Subdominants of greater importance in surface than in subsurface collections included barnacle larvae, _Anchoa mitchilli_ eggs, _Labidocera aestiva_ and _Penilia avirostris_. Two of the subdominant taxa in 202 μm mesh nets, phoronid larvae and _Parvocalanus crassirostris_, were too small to be retained in abundance in 333 μm

Table 21. A list of the numerically dominant species in August 1978 Chesapeake Bay zooplankton collections, by station and net type.

Station	N333	60B333	60B202	18.5B202
D41	Acartia tonsa Anchoa mitchilli eggs Pseudodiaptomus coronatus	Acartia tonsa Anchoa mitchilli eggs Terebellidae	Acartia tonsa Pseudodiaptomus coronatus Sagitta tenuis	Acartia tonsa Pseudodiaptomus coronatus Labidocera aestiva
D48	A. tonsa Neomysis americana Labidocera aestiva	A. tonsa Neomysis americana Labidocera aestiva	A. tonsa P. coronatus Neomysis americana	A. tonsa Sagitta tenuis Neomysis americana
E57	A. tonsa P. coronatus L. aestiva	A. tonsa Pseudodiaptomus coronatus N. americana	A. tonsa P. coronatus N. americana	A. tonsa P. coronatus N. americana
G159	A. tonsa P. coronatus L. aestiva	-no sample-	A. tonsa P. coronatus N. americana	A. tonsa P. coronatus N. americana
H95	A. tonsa P. coronatus L. aestiva	A. tonsa P. coronatus N. americana	A. tonsa P. coronatus N. americana	A. tonsa P. coronatus N. americana
H63	A. tonsa P. coronatus Uca sp.	A. tonsa P. coronatus L. aestiva	A. tonsa P. coronatus phoronid larvae	A. tonsa P. coronatus phoronid larvae
G01	A. tonsa barnacle larvae Uca sp.	A. tonsa P. coronatus unid. gastropods	A. tonsa P. coronatus unid. gastropods	A. tonsa P. coronatus unid. gastropods
G18	A. tonsa L. aestiva A. mitchilli eggs	A. tonsa unid. gastropods A. mitchilli eggs	A. tonsa unid. gastropods Labidocera aestiva	A. tonsa Mulinia lateralis L. aestiva

Table 21. (continued)

Station	N333	60B333	60B202	18.5B202
G163	A. tonsa barnacle larvae Penilia avirostris	A. tonsa L. aestiva unid. gastropods	A. tonsa unid. gastropods barnacle larvae	A. tonsa P. coronatus Parvocalanus crassirostris
F10	A. tonsa A. mitchilli eggs Evadne tergestina	A. tonsa A. mitchilli eggs L. aestiva	A. tonsa P. coronatus Anchoa mitchilli eggs	A. tonsa P. crassirostris
E48	A. tonsa A. mitchilli eggs P. avirostris	A. tonsa Hexapanopeus angustifrons N. americana	A. tonsa P. coronatus L. aestiva	A. tonsa Hexapanopeus angustifrons L. aestiva
E69	A. tonsa A. mitchilli eggs P. avirostris	A. tonsa Penilia avirostris A. mitchilli eggs	A. tonsa Parvocalanus crassirostris P. coronatus	A. tonsa P. crassirostris P. coronatus
A37	A. tonsa P. coronatus L. aestova	A. tonsa N. americana P. coronatus	A. tonsa P. coronatus N. americanan	A. tonsa N. americana phoronid larvae
C12	A. tonsa A. mitchilli eggs P. avirostris	A. tonsa A. mitchilli eggs N. americana	A. tonsa P. crassisrostris P. coronatus	A. tonsa P. coronatus P. crassirostris
B48	A. tonsa P. coronatus Metamysidopsis mexicana	A. tonsa P. coronatus P. avirostris	A. tonsa P. coronatus Penilia avirostris	A. tonsa P. coronatus Penilia avirostris
C23	A. tonsa L. aestiva Uca sp.	A. tonsa N. americana L. aestiva	A. tonsa P. coronatus N. americana	A. tonsa P. coronatus N. americana
B76	A. tonsa L. aestiva P. avirostris	A. tonsa P. avirostris P. coronatus	A. tonsa P. coronauts phoronid larvae	A. tonsa P. coronatus L. aestiva

Table 21. (continued)

Station	N333	60B333	60B202	18.5B202
C30	*A. tonsa* *L. aestiva* *E. tergestina*	*A. tonsa* *L. aestiva* *Sagitta tenuis*	*A. tonsa* *L. aestiva* *P. coronatus*	*A. tonsa* *P. coronatus* *S. tenuis*

mesh nets. Because of the dominance of *Acartia tonsa* throughout the August collections, readily apparent differences in community structure observed in March 1978 collections (Grant and Olney, 1979) were lacking.

Diversity. The Shannon index of diversity (H'), evenness (J') and Margalef's index of species richness were calculated for each collection and are listed in Table 22. Diversity (H') was generally lower in 202 μm mesh nets, especially in the small-mouthed 18.5 cm bongo net, where the observed range was 0.0949 to 1.4909. Lowest measured diversity of 0.0321 occurred at station G163 (60 bongo 202), the highest at station C23 (3.0823, 60 bongo 333). These August measures of diversity exceeded both low and high extremes measured in March 1978 collections. Lower diversities are attributed to strong dominance of many collections by *Acartia tonsa*, while the few higher diversity collections at Bay mouth stations were comprised of large numbers of meroplanktonic species.

Extreme measures of evenness (J') occurred at those stations and in net collections having similar minimum and maximum measures of diversity. The non-linearity seen in the relationship of diversity to evenness in March 1978 neuston collections (Grant and Olney, 1979) was not evident in this series of collections. Although evenness in neuston collections was somewhat higher than in subsurface collections of equal diversity, the relationship appears linear (Fig. 10).

Species richness (d) varied from a low of 0.8871 in the 18.5 cm bongo collection at G01 to a high of 5.9197 in the 60 cm bongo 333

Table 22. Diversity (H'), evenness (J'), and species richness (d) of August 1978 zooplankton collections in the lower Chesapeake Bay.

Station	Day or Night	Collection Number	Net & Type	H'	J'	d
D41	D	Z78-322	2	0.1670	0.0386	1.6439
		-323	1	1.3447	0.2861	2.9829
		-324	3	0.0476	0.0090	2.7060
		-325	4	0.2252	0.0464	2.3976
D48	N	-326	1	1.1306	0.2154	3.0505
		-327	2	0.6878	0.1260	3.3234
		-328	3	2.6640	0.4880	3.9365
		-329	4	0.2241	0.0461	2.5476
E57	N	-330	1	1.4717	0.2971	3.0873
		-331	2	0.8291	0.1616	2.8847
		-332	3	0.5217	0.0876	4.8168
		-333	4	0.5535	0.1151	2.5742
G159	N	-334	1	0.7049	0.1307	3.2200
		-336	3	0.3365	0.0661	2.2388
		-337	4	0.6236	0.1259	2.5265
H95	N	-338	1	0.6366	0.1231	2.6165
		-339	2	0.8704	0.1594	3.3038
		-340	3	0.5071	0.0913	3.2146
		-341	4	0.3578	0.0761	2.2449
H63	N	-342	1	1.5446	0.2988	2.6521
		-343	2	1.2974	0.2188	4.8940
		-344	3	0.6895	0.1263	2.8987
		-345	4	0.6468	0.1430	1.8848
G01	D	-346	1	1.1697	0.2551	2.9586
		-347	2	0.3991	0.0798	2.8083
		-348	3	0.0701	0.0153	1.6799
		-349	4	0.0949	0.0274	0.8871
G18	D	-350	1	1.1474	0.2937	1.2816
		-351	2	0.2758	0.0552	2.4773
		-352	3	0.1235	0.0257	1.9645
		-353	4	0.1595	0.0332	2.2146
G163	D	-354	1	2.0804	0.4897	2.4172
		-355	2	0.3798	0.0696	3.6218
		-356	3	0.0321	0.0062	2.4663
		-357	4	0.1756	0.0342	2.6518

Table 22. (continued)

Station	Day or Night	Collection Number	Net & Type	H'	J'	d
F10	D	Z78-358	1	1.0900	0.2522	2.0298
		-359	2	0.7192	0.1317	3.6907
		-360	3	0.5361	0.0965	3.6594
		-361	4	0.6366	0.1310	2.5026
E48	D	-362	1	0.7005	0.1473	2.3325
		-363	2	0.6728	0.1371	2.6449
		-364	3	0.1815	0.0343	2.6856
		-365	4	0.4675	0.0897	2.9979
E69	D	-366	1	1.1244	0.2392	2.4997
		-367	2	0.6187	0.1197	3.0953
		-368	3	0.1584	0.0309	2.4611
		-369	4	0.1760	0.0340	2.9459
A37	N	-370	1	0.8511	0.1659	2.8592
		-371	2	1.2400	0.2258	4.1955
		-372	3	0.3662	0.0684	2.8436
		-373	4	0.4434	0.0822	3.5682
C12	N	-374	1	0.8577	0.1646	3.2594
		-375	2	1.9240	0.3464	4.3470
		-376	3	0.4327	0.0767	3.6833
		-377	4	0.7233	0.1399	3.1217
B48	N	-378	1	1.6144	0.2994	3.4851
		-379	2	1.0138	0.1716	4.7101
		-380	3	0.9331	0.1662	3.7338
		-381	4	0.7673	0.1442	3.5149
C23	N	-382	1	2.7561	0.4812	4.3803
		-383	2	3.0823	0.5157	5.9197
		-384	3	1.5103	0.2499	5.6583
		-385	4	1.4433	0.2584	4.8648
B76	D	-386	1	1.3362	0.2546	3.3644
		-387	2	2.7628	0.4847	4.8105
		-388	3	2.2666	0.3853	4.7191
		-389	4	1.4909	0.2931	3.2049
C30	D	-390	1	0.7713	0.1622	2.5414
		-391	2	1.4799	0.2466	5.3438
		-392	4	1.1314	0.2189	3.5727

Net type: 1 = 1 meter neuston 333; 2 = 60 cm Bongo 333; 3 = 60 cm Bongo 202; 4 = 18.5 cm Bongo 202

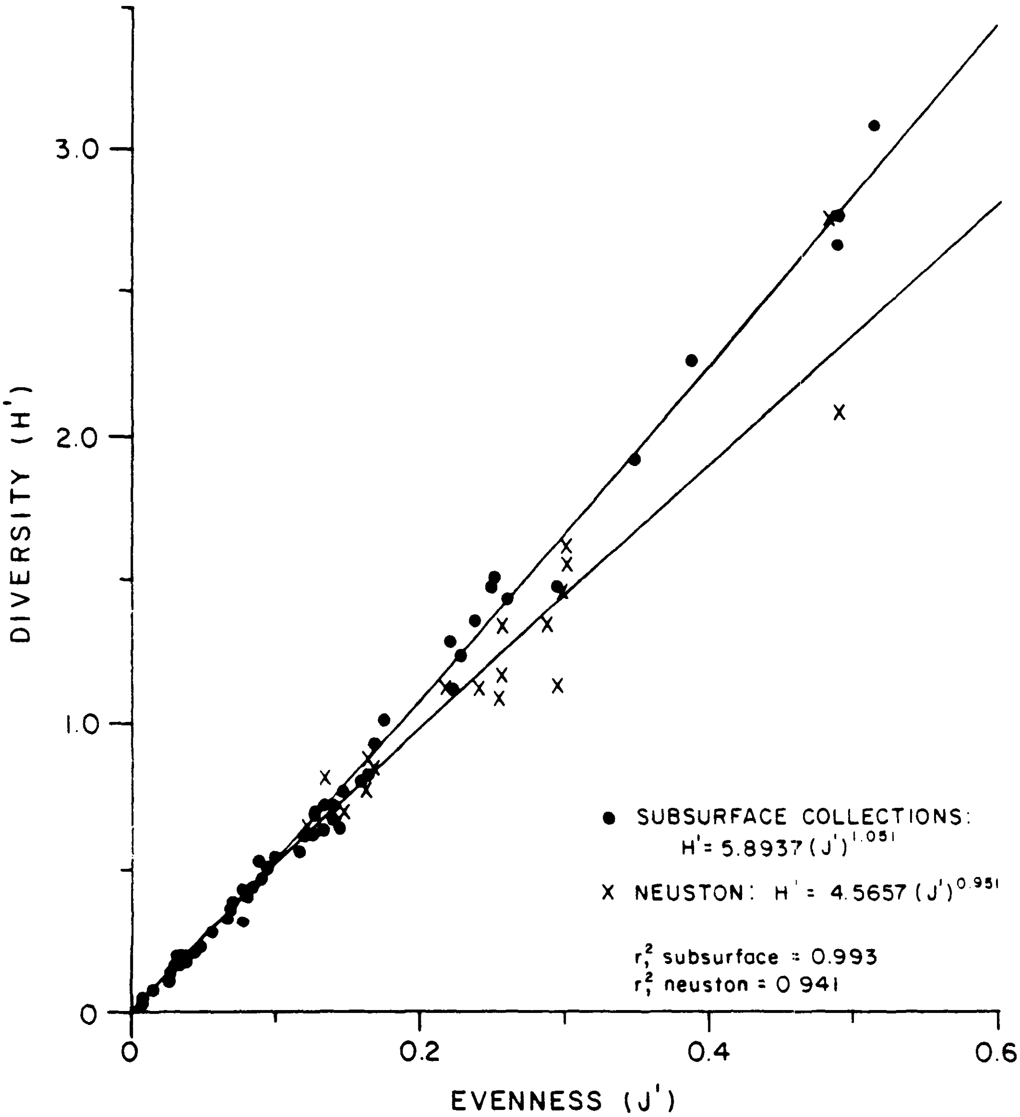


Fig. 10. Relationship of diversity (H^1) and evenness (J^1) as calculated from zooplankton collections in the lower Chesapeake Bay, August 1978.

collection at station C23 (Table 22). The former collection contained 78,603 individuals distributed among only 11 taxa, while the latter, richest collection included 35,433 individuals and 64 taxa. The mean number of species caught in the various types of collecting gear varied from just over 30 species in neuston 333 μm mesh nets and 18.5 cm bongo 202 μm nets to about 45 species in both the 202 μm and 333 μm 60 cm bongo nets (Fig. 11).

Cluster and Nodal Analysis. Normal and inverse cluster analyses were run separately for neuston (N333) and subsurface (60B333) collections. Because of the large number of species present in summer collections, species occurring in less than three of the 18 neuston or 17 subsurface collections were dropped from the inverse analyses.

Results of the cluster and nodal analyses for surface collections are shown in Fig. 12, where station groups include:

I. Bay mouth daytime stations B76 and C30, characterized by subdominants *Labidocera aestiva* and the cladocerans *Penilia avirostris* and *Evadne tergestina*.

II. Remaining daytime stations D41, E48, E69, F10, G01, G18 and G163, with a diverse list of subdominants, including spionid larvae, terebellids, *Argulus alosae*, and larvae of *Pagurus longicarpus* and *Libinia* sp.

III. Lower Bay and Eastern Shore night stations B48, C12, C23 and H95, with subdominants *Chrysaora quinquecirrha*, *Trinectes maculatus* eggs, *Pseudodiaptomus coronatus* and *Sagitta hispida*.

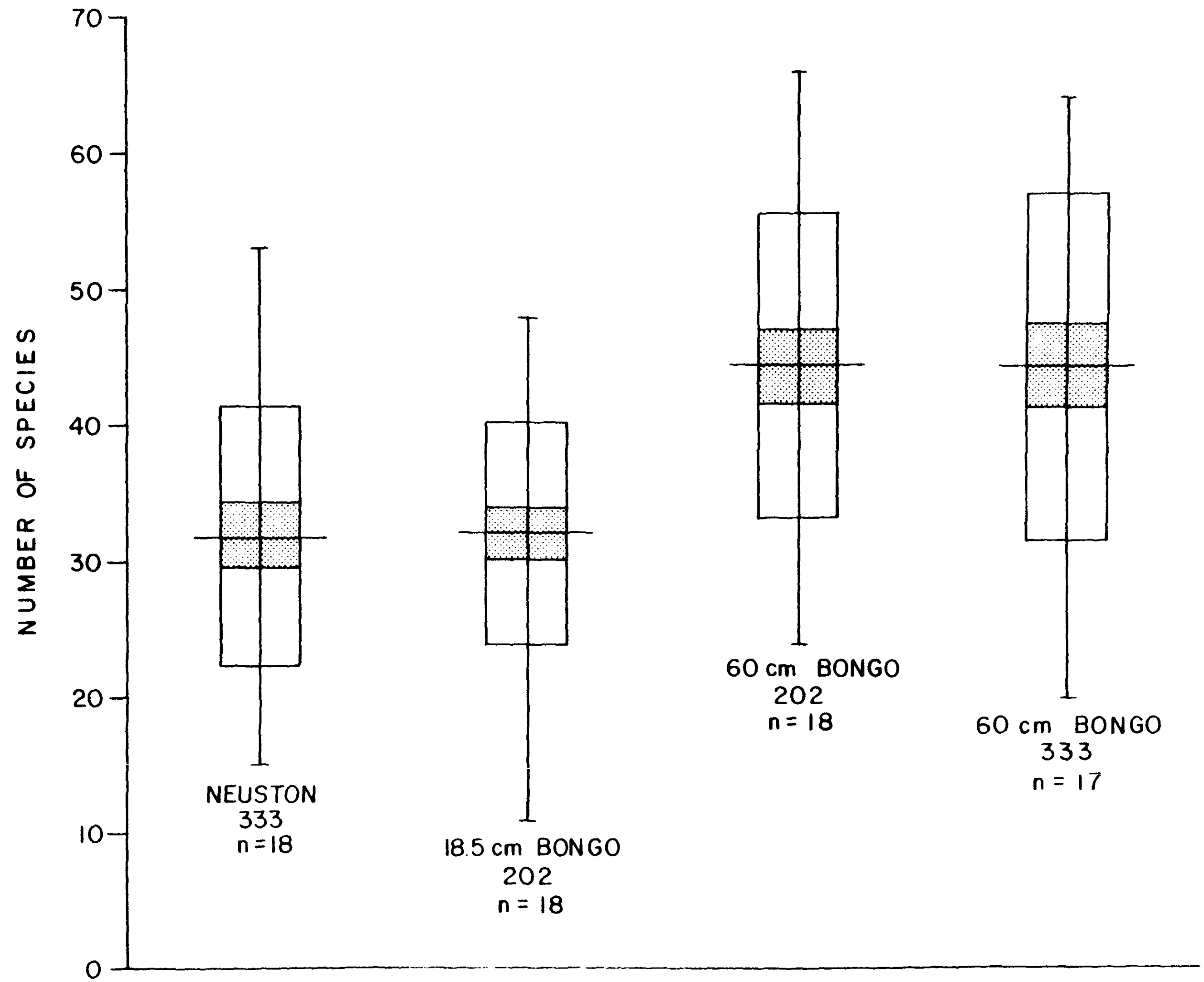


Fig. 11. The number of species caught in the four types of nets employed in the August 1978 survey: horizontal line = mean; vertical line = range; hollow bar = standard deviation; shaded bar = standard error of the mean.

IV. Other night stations (A37, D48, E57, G159, H63) with subdominants *Cynoscion regalis* larvae, *Uca* sp. larvae, *P. coronatus* and *Palaemonetes* sp. larvae.

The primary division was clearly and sharply between daytime and night collections; secondary divisions were as listed above, generally splitting day and night samples into bay mouth and up-bay or western shore stations.

Unlike March 1978 collections (Grant and Olney, 1979), species collected in August were not obviously divisible into coastal and estuarine groups. All collections were dominated numerically by the single species *Acartia tonsa*, so subdominants were necessary for description of group differences. The subdominants at bay mouth stations were not strictly coastal species, but rather characteristic of the lower, polyhaline portion of Chesapeake Bay: eggs of the hogchoker, two typical summer cladocerans, the copepods *Labidocera aestiva* and *Pseudodiaptomus coronatus*, the stinging nettle *Crysaora* and a surface-dwelling chaetognath, *Sagitta hispida*.

The range of fidelity indices (0.3-1.6, Fig. 12) was much narrower than in March 1978 collections, reflecting both the ubiquitous occurrence of *Acartia tonsa* in August and the lack of clear division between incoming coastal water and that of the Bay.

Results of cluster and nodal analyses of subsurface (60B333) collections are presented in Figure 13. Clusters of stations included:

I. Bay mouth and lower Bay stations C23, C30, B76 and E69, characterized by high species richness and an abundance of subdominants in Species Group C.

II. Low salinity daytime stations G01, G18, G163 and F10, characterized by relatively low diversity and subdominants of Species Group C, especially unidentified gastropods.

III. Western daytime stations D41 and E48 characterized by low diversity and absence of species groups A, G and H.

IV. Night stations A37, B48, C12, D48, E57, H63 and H65, characterized by an abundance of subdominants *Neomysis americana* and *Pseudodiaptomus coronatus*.

All collections were dominated by *Acartia tonsa*, resulting in distinctiveness between groups determined only from presence and abundance of subdominants. The most distinctive group of collections were those of the Bay mouth, while night collections throughout the study area were strongly influenced by excursions of *Neomysis americana* into the water column. The sharp distinction between high and low salinity stations observed in March 1978 (Grant and Olney, 1979) is lacking in August subsurface collections.

SUMMARY OF RESULTS

1. Salinity of lower Bay waters was, despite above average streamflow in April, May, July and August, mostly in the polyhaline range (> 18 $^{o}/oo$) in August 1978. Mesohaline salinities were limited to upper statons G01, G18, G159 and F10. Mean salinity was 18.69 $^{o}/oo$ at the surface and 21.88 $^{o}/oo$ at all depths sampled.

Figure 12 (facing page). Station and species clusters from August 1978 neuston collections, with their relationship shown by indices of fidelity. Taxa within species groups (in order shown in figure) are as follows:

Group A

Evadne tergestina
Penilia avirostris

Group B

Acartia tonsa
Labidocera aestiva
A. mitchilli eggs
Pseudodiaptomus coronatus

Group C

Uca sp.
Hexapanopeus angustifrons
Neomysis americana
Palaemonetes sp.
Callinectes sp.
barnacle larvae

Group D

Mulinia lateralis
Membras martinica
Gammarus mucronatus
Aegathoa oculata
Nassarius vibex
atherinid larvae
unid. gastropods
sciaenid eggs

Group E

Metamysidopsis mexicana
Pinnotherid larvae
Sagitta tenuis
Anchoa sp. larvae
phoronid larvae

Group F

Centropages velificatus
Paracalanus quasimodo
T. maculatus eggs
Lucifer faxoni
Pinnotheres ostreum
Mysidopsis bigelowi
Pinnixa sayana
P. chaetopterana

Group C

Nereis succinea
Lestrigonus bengalensis
Harmothoe sp.
Cynoscion regalis
Microprotopus raneyi

Group H

Pagurus longicarpus
Libinia sp.
Upogebia affinis
xanthid larvae
Pinnotheres maculatus
Gobiosoma sp.
Neopanope sayi
Hypsoblennius hentzi
Sagitta hispida
Anchoa mitchilli
Epitonium sp.
Ampithoe longimana
Panopeus herbstii

Group I

Limulus polyphemus
Syngnathus fuscus
Lironeca ovalis
Argulus alosae
spionid larvae
Chrysaora quinquecirrha
Gobiesox strumosus
Crangon septemspinosa
Melita sp.
Sphaeroma quadridentatum
terebellids

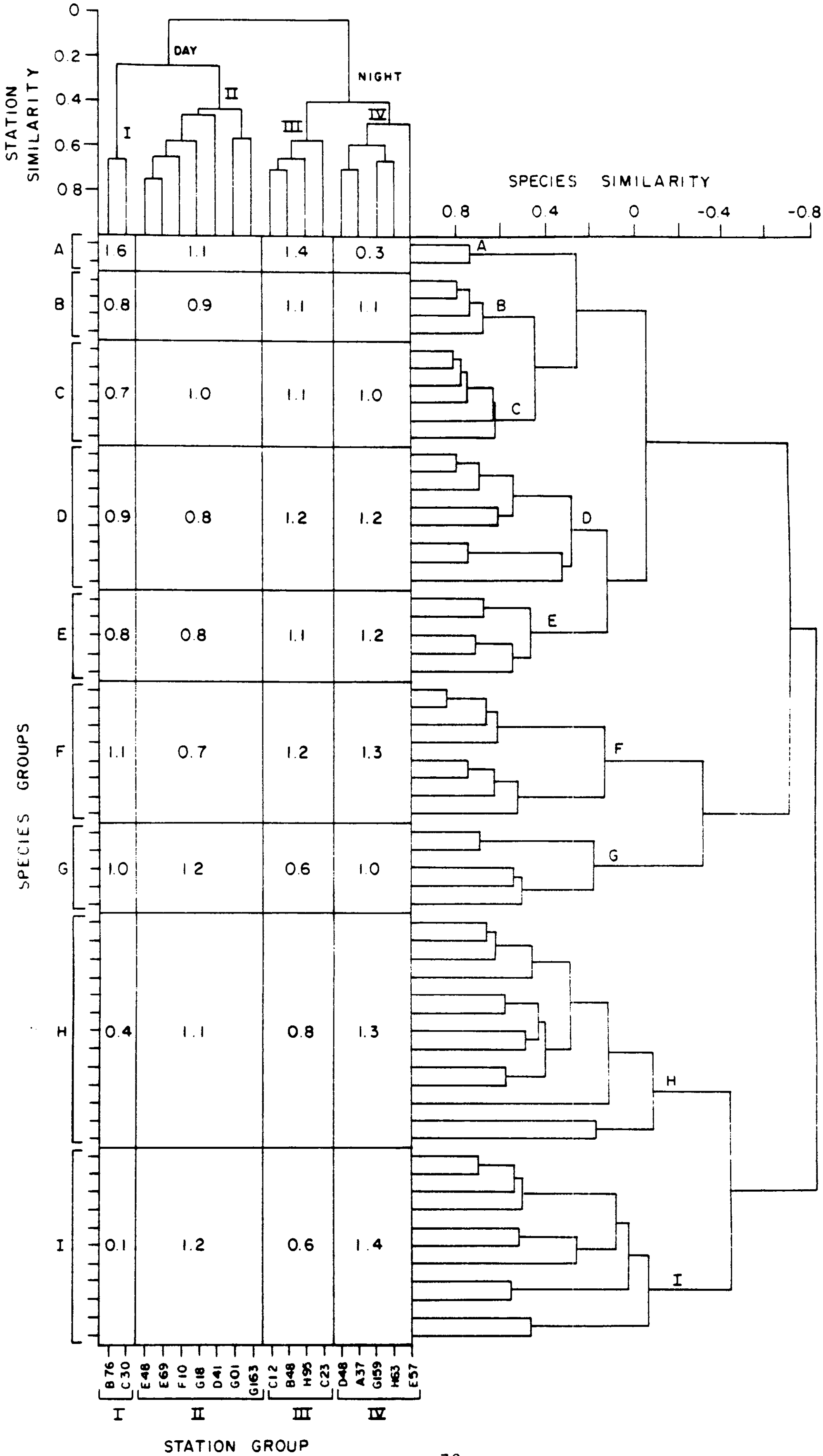

STATION SIMILARITY
0
0.2
0.4
0.6
0.8
DAY
NIGHT
I
II
III
IV
SPECIES SIMILARITY
0.8
0.4
0
-0.4
-0.8
SPECIES GROUPS
A 1.6 1.1 1.4 0.3
B 0.8 0.9 1.1 1.1
C 0.7 1.0 1.1 1.0
D 0.9 0.8 1.2 1.2
E 0.8 0.8 1.1 1.2
F 1.1 0.7 1.2 1.3
G 1.0 1.2 0.6 1.0
H 0.4 1.1 0.8 1.3
I 0.1 1.2 0.6 1.4
B76 C30 E48 E69 F10 G18 D41 G01 G163 C12 B48 H95 C23 D48 A37 G159 H63 E57
I II III IV
STATION GROUP

Figure 13 (facing page). Station and species clusters from August 1978 bongo (333 m mesh) subsurface collections with their relationships shown by indices of fidelity. Taxa within species groups (in order shown in figure) are as follows:

Group A

Callianassa biformis
Pinnixa sayana
Palaemonetes sp.
phoronid larvae
spionid larvae
Panopeus herbstii
Ovalipes ocellatus
Eucalanus crassus

Group B

Callianassa atlantica
Naticidae
Unid. pinnotherids
Centropages typicus
Eucalanus pileatus
Mysidopsis bigelowi
Crangon septemspinosa
Chrysaora quinquecirrha
Harmothoe sp.
Cynoscion regalis
Littorina irrorata
Naushonia crangonoides

Group C

Hexapanopeus angustifrons
Upogebia affinis
Uca sp.
Sagitta tenuis
Anchoa sp. larvae
Mulinia lateralis
Nassarius vibex
Labidocera aestiva
Pseudodiaptomus coronatus
Neomysis americana
A. mitchilli eggs
Acartia tonsa
Evadne tergestina

Group C (continued)

Penilia avirostris
Callinectes sp.
Pagurus longicarpus
Libinia sp.
sciaenid eggs
unid. gastropods

Group D

Peprilus triacanthus
Etropus microstomus
Lestrigonus bengalensis
Symphurus plagiusa
terebellids
Hypsoblennius hentzi

Group E

Euceramus praelongus
Temora turbinata
Lucifer faxoni
Crepidula sp.
Pinnotheres ostreum
Libinia dubia
Corophium lacustre
Sagitta hispida
Batea catharinensis

Group F

Gobiosoma sp.
barnacle larvae
Pinnixa chaetopterana
T. maculatus eggs
Ogyrides alphaerostris
Neopanope sayi
Pinnotheres maculatus
Gobiosoma ginsburgi
Alphaeus normanni

Group G

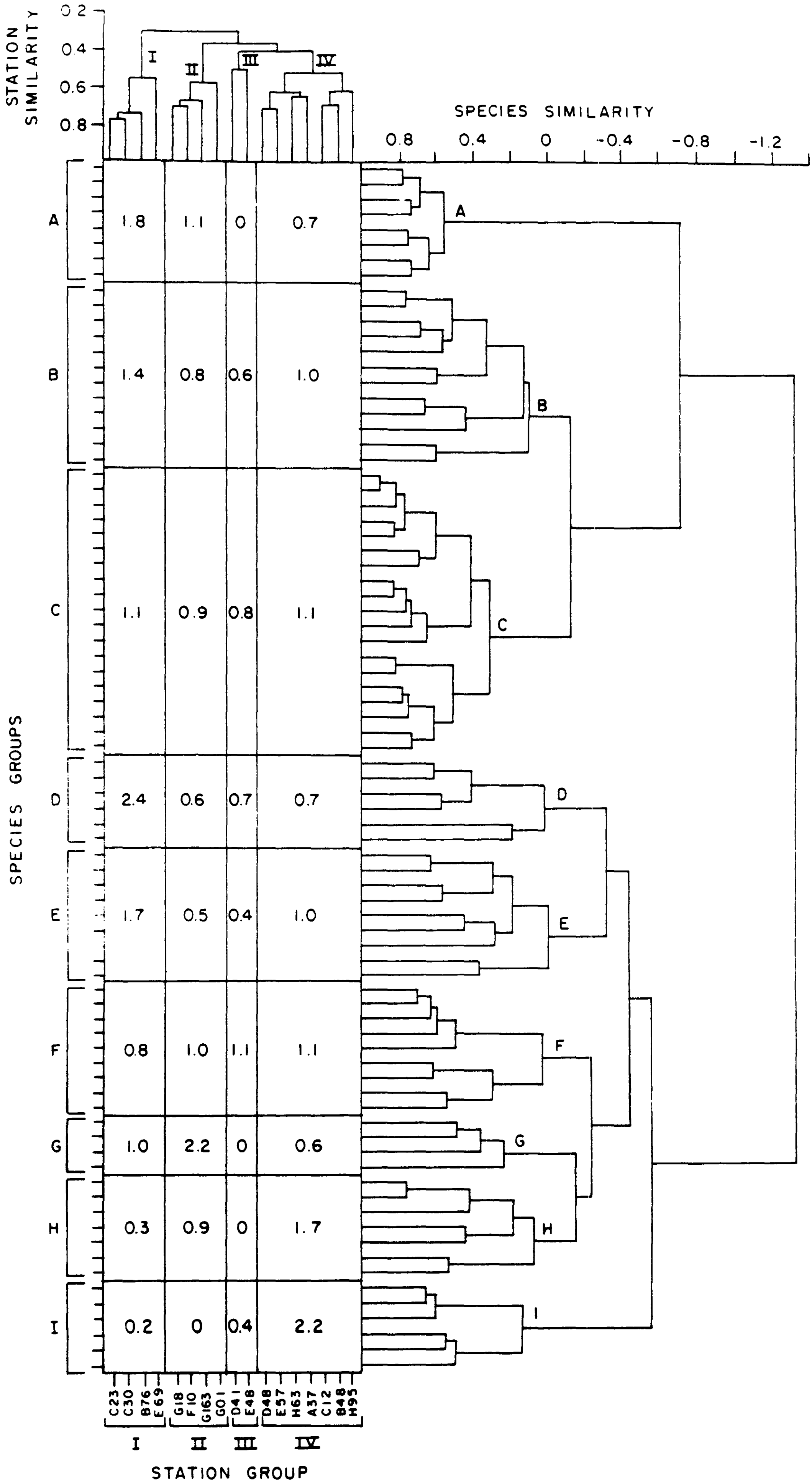
Syngnathus fuscus
Trinectes maculatus
Emerita talpoida
unid. xanthids

Group H

Membras martinica
Anchoa mitchilli
Aegathoa oculata
Gammarus mucronatus
Metamysidopsis mexicana
Pseudeurythoe ambigua
atherinid larvae

Group I

unid. decapods
Ovalipes sp.
unid. polychaetes
Oxyurostylis smithi
Ampelisca vadorum
Epitonium sp.


STATION SIMILARITY
0.2
0.4
0.6
0.8
I
II
III
IV
SPECIES SIMILARITY
0.8
0.4
0
-0.4
-0.8
-1.2
SPECIES GROUPS
A
B
C
D
E
F
G
H
I
1.8 1.1 0 0.7
1.4 0.8 0.6 1.0
1.1 0.9 0.8 1.1
2.4 0.6 0.7 0.7
1.7 0.5 0.4 1.0
0.8 1.0 1.1 1.1
1.0 2.2 0 0.6
0.3 0.9 0 1.7
0.2 0 0.4 2.2
C23 C30 B76 E69
G18 F10 G163 G01
D41 E48
D48 E57 H63 A37 C12 B48 H95
I
II
III
IV
STATION GROUP

2. Coastal waters at the bottom in the Bay mouth (> 30 °/oo) were 24-25°C, while surface temperatures at upper estuarine stations exceeded 27°C.

3. Highest chlorophyll-*a* measurements at the surface occurred in the middle and western portions of the survey area, with a range of values similar to those in March 1978.

4. Displacement volume of 202 μm mesh collections generally exceeded that of 333 μm mesh collections (9 of 13 paired tows), as expected, but high estimates of biomass from the small-mouthed 18.5 cm, 202 μm mesh, nets are unexplained by mesh-size differences alone. Biomass estimates were extremely variable between different nets at a given station, with no evidence of correlation between dry weight and displacement volume.

5. Over 175 taxa of zooplankton occurred in August 1978 collections, many of them at every sampled station. Distribution and abundance of these species were described within major taxonomic categories.

6. Species found predominantly in the surface layer (neuston nets) included *Gammarus mucronatus*, *Aegathoa oculata*, *Penilia avirostris*, *Palaemonetes* sp. larvae, *Membras martinica*, and *Hypsoblennius hentzi* larvae. *Uca* sp. larvae and barnacle larvae were an order of magnitude more abundant in the surface layer.

7. All collections, despite location or net type, were dominated by the copepod *Acartia tonsa*. Important subdominants included *Anchoa mitchilli* eggs, *Pseudodiaptomus coronatus*, *Neomysis americana*,

Labidocera aestiva, *Penilia avirostris*, and larvae of *Uca* sp. and *Hexapanopeus angustifrons*.

8. Diversity ranged from H' = 0.0321 to 3.0823 and was generally lowest in 202 μm mesh nets, especially the small 18.5 cm net. Large numbers of meroplanktonic species contributed to higher diversity in August compared with March 1978 collections. Evenness (J') ranged from 0.0090 to 0.5157, and species richness (d) from 0.8871 to 5.9197.

9. Primary division of neuston collections by cluster analysis occurred between night and day collections. Secondary divisions were between Bay mouth and remaining stations.

10. The clusters of subsurface 333 μm mesh collections primarily split between a small group of Bay mouth stations and the remainder of stations. Secondary clustering showed the influence of time of day, with species such as *Neomysis americana* entering the water column at night and attaining subdominance in subsurface collections.

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